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TROPICAL AGRICULTURE is published by the Imperial College of Tropical Agriculture, St. Augustine, Trinidad, British West Indies. Subscription rates can be obtained at the College from the Managing Editor at the above address, or from the Secretary of the College, 40, Norfolk Street, Strand, London, W.C. 2, England. Authoritative articles for publication should be submitted to the Managing Editor for consideration. Cables : Stomata. Phone : St. Augustine, 94419. *It is understood that opinions expressed or recommendations made in signed articles or in articles of which the source is named are those of the author and do not necessarily represent the policy or opinion of the College Authorities.* Increasing numbers of inquiries are being received from the various parts of the tropics which can be answered only by persons possessed of an intimate knowledge of local conditions. Enquirers should first satisfy themselves that their local Department of Agriculture is not able to supply them with the desired information before communicating with us. Correspondence which will be replied to is invited on all other matters pertaining to tropical agriculture and related subjects.

EDITORIAL NOTE

WITH this issue, *Tropical Agriculture* commences to appear with the "new look". The changes in appearance and in style of printing, acceptable as we hope they will be to our readers, are outward and visible signs of changes which are being made in the contents and scope of the Journal.

Hitherto *Tropical Agriculture* has been chiefly a medium for the publication of communications on original investigations in the field of tropical agriculture and its applied cognate sciences, together with some critical reviews or notes of advances and problems in this field. It is intended now to develop this latter aspect to a much greater extent, and the present number is a first step in that direction.

Tropical Agriculture will continue to be first and foremost an organ of the Imperial College of Tropical Agriculture, aimed primarily at being of service, through its staff and past students, to all agricultural workers in the tropical parts of the British Commonwealth. Past students of the College, to the number of many hundreds, are now a large proportion of those responsible for the work of administering or managing government departments of agriculture and private agricultural enterprises throughout the tropics.

By the very nature of their jobs, often out of close touch with scientific and technical institutions and libraries, it is usually well-nigh impossible for them to keep properly abreast with the latest developments in their subject. We hope to be able to do more to supply this need.

The library of the Imperial College of Tropical Agriculture receives over five hundred scientific and technical periodicals together with copies of most new books in the field of agriculture and its related sciences, and members of the College Staff are engaged in teaching or research in most branches of this field. We shall endeavour to use these facilities so that our readers can count on finding in *Tropical Agriculture* up-to-date information on new advances of knowledge and thought in their own subjects. Of course we cannot undertake to cover the whole ground so thoroughly that fully detailed information in this vast field can be found just in these pages ; but by a combination of reprints, review articles, book reviews, extracts from or references to published literature, and the like, we shall try to make it possible for our readers to know how and where they can get such more detailed information in whatever subject they wish to follow up.

Contributions of original articles, either dealing with their authors' own investigations, or reviewing work or developments in any particular subject, will still be welcomed, especially if they are of more than local interest and deal with questions of direct or potential practical importance.

We shall always be very glad to receive from our readers criticisms and suggestions for the improvement of *Tropical Agriculture* and the better attainment of the objects we have outlined above.

REVIEW ARTICLES AND BOOK REVIEWS

FOOD PRODUCTION AND THE WORLD'S RESOURCES

QUO VADIMUS?

"*In the sweat of thy face shalt thou eat bread.*"—(Genesis)

In his Presidential address to the Second International Congress of Crop Protection (1) Viscount Bledisloe stressed the gravity of the world's food situation. Most people are well aware that there is a general shortage of food, but are inclined to believe that this is a temporary after-effect of the disruptions caused by war, and that before long there will be a return to pre-war plenty. (But is not this "pre-war plenty" itself an illusion? It certainly existed in some countries, even to the extent of apparent over-production and consequent wholesale destruction of foodstuffs; but it is probably true that the population of the world as a whole has never, and certainly not in the period between the last two great wars, been adequately nourished.)

But, Lord Bledisloe points out, the world's population is increasing at the rate of at least 25 million a year at the present time, and this rate of increase will rise for at least the next two or three decades, whereas the increase in the production of food, especially the two main cereal crops, wheat and rice, is not rising *pari passu*. "In other words, the world now faces an unending war against food shortage."

Much of course can still be done by expanding the area of cultivable land, by soil conservation, and by producing a greater output of food from certain areas already in cultivation, but the necessary increment can no longer be obtained solely from the application of fertilisers. Crop protection, and the conservation of produce in storage, are becoming more and more important, if the battle against dwindling food supplies is to be won.

Lord Bledisloe considers that a conservative estimate of the loss caused to food crops by insects, fungi, viruses, rats, birds and other pests, but excluding weeds, is at least 30 per cent. (The present writer suggests that this is an ultra-conservative figure, but his experience is limited to tropical countries where the damage caused, especially by insects, is much greater than it is in the temperate zone.) He gives a number of examples of outstanding losses caused by a variety of pests in several countries, and then proceeds to stress the need for further research :—not only on insecticides, on which very great advances have been made within the past five years and are still being made, but also on methods of applying them. Although addressing a Congress with "a strong chemical bias" he points out that there are many other aspects of crop protection besides the use of chemicals. Such methods as breeding varieties of plants resistant to a particular pest or disease, or biological control, are, when successful, far superior in cheapness, safety, and permanence of control to the most perfect insecticide or fungicide that could be imagined.

(1) Reported in *Chemistry and Industry*, December 24th, 1949, pp. 899–904.

Lord Bledisloe ended his address with a challenge The majority of the human race is undernourished : the preventible loss of food from the ravages of pests is " of staggering dimensions and constitutes a disgrace to an age which boasts of its civilization, its amazing scientific discoveries and its so-called progress." Surely therefore we must accept this challenge and " thus ward off as great and certainly a more probable peril to humanity than the atom bomb or a third world war."

With this conclusion of Lord Bledisloe's, no one will disagree. But is it certain that all that can, and undoubtedly should, be done by minimising the loss of food caused by pests can be more than a temporary palliative ? (For at the best, which certainly will not be attained for many years, however greatly research is intensified, this can only increase food production by about 40 per cent. (70 increased to 100) according to Lord Bledisloe's calculations, or at most to double its present level by the estimates of such pessimists as myself.) On this point there is a wide divergence of opinion. According to Vogt (2) the two curves, of population increase and the production of food, have already crossed and are ever more rapidly drawing apart. A similar gloomy outlook is foreseen by Aldous Huxley (3), though in the same pamphlet Sir John Russell takes the opposite point of view, believing that scientific improvement in agricultural technique is more than capable of coping with the predicted increase in population. In an article reviewing this pamphlet the 'Economist' (14th May, 1949, p. 877) while admitting that the population as a whole is undernourished, maintains that the position is not getting worse and will not, at any rate for the next decade or two.

In the same issue of the 'Economist' there is a full-page advertisement of the International Harvester Company, the caption of which is " You were wrong, Dr. Malthus ". It is true that Malthus was wrong 150 years ago, but it is mere wishful thinking to say that the " Neo-Malthusians " are therefore necessarily wrong today. One of the main factors that disproved Malthus' hypothesis was the opening up of North America and the consequent productoin of vast quantities of food from a new area. The only similar large areas that remain to be exploited today are the Amazon basin and tropical Africa and it is very doubtful if these can become producers of food on a large scale, for reasons of soil fertility and labour shortage, if for nothing else.

The optimists claim that improvements in agriculture are raising food production at about 1½ per cent. per annum while the population is increasing at only just over 1 per cent., and that therefore there is no problem. Even if these rates are correct they neglect the fact that the standard of living is, quite rightly, getting higher, and that the science of medicine is also improving, possibly faster than that of agriculture. The proportion of people that outlives the productive age, and therefore has to be fed by the younger population groups, is consequently on the increase.

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(2) *Road to Survival*—William Vogt. Gollancz, 1949. This is what the Americans call a "must book". It should be read by everyone interested in any aspect of agriculture or economics, though I do not say that one should necessarily agree with all or even any of its conclusions. It has the not too common merit, for a book on such a subject of being extremely readable.

(3) *Food and People*—Aldous Huxley and Sir John Russell. Bureau of Current Affairs, 1949.

It may well be a fortunate circumstance if the drug Paludrine has not come up to its original expectations for the cure of malaria (since it appears that there are strains of Plasmodium that are resistant to it). For is there "any kindness in keeping people from dying of malaria so that they could die more slowly of starvation." ? (Vogt, *loc. cit.* p. 13).

And not only medical science : if one half of what has been written in the popular press about Antrycide, the new drug that cures trypanosomiasis in cattle, should prove to be true, it may well turn out to be a curse in disguise. In 1937 I suggested (4) that the tsetse fly should be considered as the guardian of the soil of Africa until such time as we should learn, not only to eradicate the tsetse, but to apply an effective soil conservation policy to land that had been reclaimed from the tsetse. This view met with considerable criticism and was even misrepresented as being an argument that research on tsetse eradication was undesirable. Needless to say, that was not my intention, which was merely a plea for anti-erosion methods to be practised in conjunction with tsetse reclamation.

Swynnerton, the father of tsetse research, who was killed in a flying accident on duty in 1938, is buried on the top of a hill overlooking the tsetse research station at Shinyanga in Tanganyika. His epitaph reads *Si monumentum requiris, circumspice* and was of course intended to refer to the miles and miles of populated land that are visible from the top of this hill, land that before the control of the tsetse was uninhabited. But when I was last at Shinyanga some five years ago, one could also see severe soil erosion due to overgrazing—not a very good monument to a remarkable man. Vogt (*loc. cit.* p. 30) holds the same opinion that I do on the value of the tsetse fly as a protector of the soil.

As an entomologist, I naturally do not underestimate Lord Bledisloe's views on the importance of crop protection. But the problem of feeding the population of this planet is now far more complicated than that of "making two blades of grass grow where one grew before". Vogt (p. 279) maintains that "all possible conservation measures are futile unless human breeding is checked." Apart from the difficulties of doing this, educational, religious and other (to which Vogt is fully alive), I suggest that in the present state of international immorality, for any one great power voluntarily to reduce its population would be as suicidal as making a free distribution of atomic bombs. Even that course would be unlikely to solve the problem, for though a third world war would probably destroy at least half the population of the planet, instead of the paltry 15 or 20 million that were killed in each of the last two wars, it would set back food production to an even greater extent. Then, in the words with which Vogt concludes his book, "Like Gaderene swine, we shall rush down a war-torn slope to a barbarian existence in the blackened rubble."

If my attitude is thought to be unduly pessimistic, it may be because on the very day that the Editor asked me to write an article on Viscount Bledisloe's address, the following appeared in the *Trinidad Guardian.*

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(4) Kirkpatrick, T. W.—'East Africa and the Tsetse Fly' *E. Afr. Agric. Jr.* 2 *pp.* 411–415, 1937.

"U.S. TO DUMP 25,000,000 BUSHELS OF POTATOES 'NOBODY WILL BUY'

WASHINGTON, Feb. 1 (Reuter)—The U. S. A. is planning to destroy about 25,000,000 bushels of surplus potatoes—the first major food-dumping project since the start of the last war.

Mr. Charles Brannan, Secretary of Agriculture, said yesterday that he hoped to get rid of about half the total of 50,000,000 bushels surplus, which nobody will buy, by turning the potatoes into cattle feed and by domestic "give away" programmes. The remainder, he said, would be "disposed of in the least expensive way which will, at times, mean dumping them". The surplus would probably be destroyed by : (1) Dumping them where they would freeze and rot and later ploughing them into the ground. (2) Soaking them with oil and burning them, or, (3) Soaking them with chemicals to make them unfit for human consumption."

Comment is superfluous. But as I headed this somewhat amorphous article with a quotation from Genesis, I will end it with a more cheerful one from the Rhapsodies of the Unknown Prophet.

"Ho, every one that thirsteth, come ye to the waters,
And he that hath no money ; come ye, buy, and eat ;
Yea, come, buy wine and milk
Without money and without price.
Wherefore do ye spend money for that which is not bread ?
And your labour for that which satisfieth not ?
Hearken diligently unto me, and eat that which is good,
And let your soul delight itself in fatness."

You can take your choice. T.W.K.

FREEDOM FROM WANT

Symposium edited by E. E. de Turk for the American Association for the Advancement of Science. Chronica Botanica Company, Waltham, Mass., U.S.A., 1948. *Pp.* 72, *with* 13 *tables and illustrations in paper covers. Price* $2.00 *U.S.* (*Chronica Botanica*, **11**, 4, 211-283).

THE realization that the population of the world is becoming dangerously large for its supply of food has been growing in recent years. It achieved major political expression at the Hot Springs conference on Food and Agriculture in 1943 ; and the appreciation of the need for action led to the foundation of the Food and Agriculture Organization in 1945. The present review relates to a contribution to the literature of the subject. "Freedom from Want" consists of six papers originally delivered at the meeting of the American Association for the Advancement of Science held at Boston in 1946. The authors are agriculturists or economists and are members of the United States Department of Agriculture or of American Universities.

Three of the papers may be called general, three particular. Tolley and Salter deal with the problem of whether or not the world could produce enough food to provide at a satisfactory nutritional level for the estimated population of 1960. They conclude that the world could, in fact, do this

if there were adequate advances in the practical applications of the agricultural sciences. The three main means by which the increase in production of food could be attained are : (1) improvements in agronomy especially, perhaps, in manuring and soil-management ; (2) the use of plant-breeding ; (3) the partial development as new agricultural areas of certain temperate podzols and tropical red soils which are at present largely uncultivated. The arguments and figures of Tolley and Salter seem convincing to the reviewer. Perhaps, however, it should be emphasized that their conclusions represent a potentiality that could be realized only by the most prodigious practical efforts ; also that they do not seriously look beyond 1960.

In the third general paper Black views the matter as an economist. He considers that population rather than supply of food is the critical feature of the problem and looks to a natural stabilization of population consequent upon industrial development and relief of pressure upon the land. From the viewpoint of nutrition, of course, the important thing is how fast this stabilization takes place. Can it happen soon enough to avert a major shortage of food ; or will population overtake food-supplies so to speak, despite all efforts to increase production ? Black gives no direct answer to these questions and, indeed, perhaps none is possible now. But it is necessary to bear this longer view in mind when considering Tolley's and Salter's papers. Even the achievement of a satisfactory production of food in 1960 (and that in itself would be a tremendous task) gives little encouragement for the years to follow if population is still growing and the resources of the world in land are shrinking.

In the other three papers, some means of increasing production of food are considered in detail. Quisenberry very ably expounds the truly magnificent achievements of plant-breeding in the United States of America and makes some estimates of possibilities for their future. Morrison reviews the relative efficiency of farm animals. McCall discusses practical aspects of the application of scientific research to agriculture. Interesting in themselves, these three papers add little to the general picture though they do indicate how far the agricultural sciences outstrip agriculture in all but a very few countries.

" Freedom from Want ", then, poses the problems and indicates, in an able and interesting manner, some of the first steps towards their solution. It hardly touches the main issue, that is, the nature of the ultimate balance (or unbalance as one may fear) between man and his food.

The book is well printed though the illustrations (with two exceptions) are neither useful nor ornamental.

N.W.S.

THE SOIL AND THE SEA

A Symposium, edited by T. I. Williams. Saturn Press, London, 1949. *Pp.* 242. *Price :* 10*s.* 6*d.*

" Immense rewards could be quickly reaped if there was as great an "interest in biology as there is in physical science ". (Introduction). This theme is developed in the eighteen articles, each written by a specialist, which comprise this book. Among them are several of interest to agriculturists, for example,

Science and the Farmer by J. A. Scott Watson ; *The Scientist's Guide to Global Food* by F. E. le Gros Clark ; *Chemical Stimulants for Crops* by R. Clements ; *Chemurgy* by M. K. Schwitzer and *Crops without Soil* by D. P. Hopkins, while others are of interest to biologists, notably, *Artificial Fertilisers in Fish Farming* by D. T. Gauld ; *Migration of Vertebrate Animals* by J. Gray ; *The War Against Rodents* by A. Barnett ; and *The Senses of Rats* by B. Vesey-Fitzgerald.

These articles describe recent biological researches and offer suggestions for the practical implementation of processes whereby biological science can benefit mankind. Thus, crops could be increased enormously by the wider and more skilful use of fertilisers and weed-killers and by the breeding of more productive crop varieties capable of resisting pests and diseases, as well as by the extended use of new kinds of insecticides and fungicides. The application of biological research to the fishing industry promises greatly to increase the supply of edible marine products which would greatly help to satisfy the increasing demand for nitrogenous foods.

F.H.

THE WEALTH OF INDIA

VOL. I. RAW MATERIALS. *Council of Scientific and Industrial Research, Delhi*, 1948. *Pp.* 254. *Price :* 24*s*.

THIS attractive book is the first part of Volume I of a new six-volume encyclopedia of India's economic products and industrial resources. It will take the place of Watt's well-known work on the economic products of India which was published in six parts during 1889 to 1899, and summarised in a single book published in 1908. Since then, India has become a semi-industrial state and her indigenous industries have been rapidly extended and much new knowledge acquired. The present compilation is the effort of a large number of specialists organised in seven sub-committees under an editorial committee and an advisory board with Dr. B. L. Manjunath as secretary and editor-in-chief, and sponsored by the Council of Scientific and Industrial Research.

The work will deal with 4,000 topics in alphabetical order. Of these, about 3,600 deal with plants ; the rest concerns animal products, mineral resources and specific industries. Each is divided into two parts, one dealing with raw materials, the other with industrial products. The sources of information are fully indicated and numerous references to further work are given. The presentation of botanical subjects includes a brief account of each plant, genus, a list of economic species, synonyms and references to botanical authorities.

The first part of Vol. I contains topics beginning with A and B. There are 7 coloured and 39 black-and-white plates. The book is bound in dark-blue art-leather and is 11 by 8½ inches in size. Besides having " great value to the builders of New India " (to quote from Prime Minister Nehru's foreword), this encyclopedia will command the attention of all who are interested in the utilisation of the world's resources.—F.H.

MECHANIZATION AND FARM MACHINERY

AN APPROACH TO MECHANIZATION IN TROPICAL AGRICULTURE

By

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In the tropics agricultural enterprises are usually either on a peasant, or on a capitalist, scale. Mechanization of the capitalist estates and plantations is not such a great problem as the mechanization of the peasant. Not only is the small cultivator's land likely to be particularly rough and unsuited to the use of machinery, but his economic status is certain to be low. At one extreme, many millions of subsistence farmers have virtually no cash economy, and therefore no means by which even the simplest equipment could be introduced to, and maintained in, their agriculture. In other areas the peasant may, either alone or as a member of a co-operative, be able to buy small-scale machinery, or he may be able to afford the services of an agricultural contractor for his heavy cultivations.

In contemplating mechanization in a tropical agriculture we are faced with two premises. First, there is no benefit in mechanization for its own sake. Secondly, the fashions of mechanization are set in temperate agriculture, and to a great extent we, in the tropics, must follow since only most exceptional economic circumstances would put us into a position in which we could specify our fundamental requirements and expect them to be filled by industry.

Considering our first premise more fully it is evident that mechanization is mainly an effect of economics. The two important questions are (*a*) will it pay now ? and (*b*) will it do harm ?, or in other words, will it continue to pay in the future ? The answer to the first question depends upon the type of agriculture. It has been suggested (1) that the replacement of working animals by power units would release for food production land which otherwise was used to feed living traction engines. This argument has particular appeal to the engineer who visualises the capital tied up in, say, a pair of working oxen put to more immediately productive use, their feeding stuffs going to a milk cow, and their bulky bodies which together develop about 1-2 horsepower* being replaced by a small compact power unit of five or six horsepower. Such a unit would cost, perhaps, $1,000 and therefore would be cheaper than 2 oxen by about $100 per unit horse-power theoretically available for work. The fallacy of this argument will be apparent to those who know agriculture. A machine can only be considered if it will do a given job more cheaply than animals or man, or if it can do it better.

From an address to the Agricultural Society of Trinidad and Tobago

* Zebu oxen in Trinidad.

It is interesting to compare the relative rates of work of oxen and tractors in Trinidad. Including all the time spent in preparing for work, going and coming from the field, stoppages and adjustments, 2 oxen work quite well to plough one acre in 12 hours. A tractor of 20 d.b.h.p. will plough $\frac{1}{4}$ to $\frac{1}{2}$ acre per hour. With a disc cultivator two oxen will plough about 1/3 acre per hour whereas a 20 d.b.h.p. tractor will plough $1\frac{1}{2}$ acres per hour. The cost of the power in this particular instance (as calculated on the College Farm, I.C.T.A.) is comparable—about $1.08 per acre with oxen and 80c. per acre with the tractor and in this particular operation the tractor does a better job, because of its higher speed.

Will the machine do any harm ? This depends entirely on how, and for what purpose, it is used. Against the machine it can be said that it may encourage speed at the expense of husbandry and future generations of agriculturists. It may cause unemployment, although it must in fairness be said that mechanization has mainly developed as a *result* of labour shortage. It may limit the range of crops produced in an area to those which favour machinery, and so throw farming off balance. On the other hand, the greatest argument in favour of the machine is that it can lighten human toil ; it can make for social stability in agriculture. In the U.S.A. it is recognised as having given men more leisure and having enabled them to take part in religious, social and community work (2). It may make possible certain jobs which could never before be done—such as the incorporation of green manures with the soil on a large scale. It may enable the same number of employees to produce more, more easily and more profitably. It may enable more land to be brought under the influence of good husbandry. The man wielding an agricultural fork is probably unaware that in digging his acre of land he is physically moving 1,000 tons of soil.

Our second premise is that the fashion has been set and we must follow, selecting for our agriculture machines which will work in the tropics, but were not specifically designed for us. We must therefore, be aware of certain difficulties peculiar to the establishment of machinery in the humid tropics.

Many tropical soils adhere to metal surfaces, thus changing their effective working shape in cultivation. We have an enormous weed growth quite atypical of northern mechanized countries. We have special harvesting problems arising out of bulky crop growth, humidity and wet weather. Generally speaking the cultivators have had little contact with mechanisms and are often unwilling to try something new. Owing to the climate, and other factors, more labour is required to operate and upkeep a machine in the tropics. Tropical agricultural holdings are mostly either big or small whereas most agricultural machinery (and this means the cheapest) is manufactured for the medium-sized farms of Europe and America.

It is therefore important that we should approach mechanization carefully in four logical stages :—

1. Trial and selection.
2. Modification where necessary.
3. The development of techniques where necessary.
4. Advisory work—or the sharing of experience.

Trial and Selection

Ideally, trial and selection should be done on the spot, but preliminary information about the performance of machines can be got from the literature. As an example of the factors which enter into the selection of a machine let us consider the category of small tractors—one which is claiming a lot of interest at present and which may, in time, benefit the greatest number of cultivators. In the tropics the power required for cultural operations is almost always higher than in the temperate zone, and the 1-2 h.p. tractors are unable to cope satisfactorily with light work. A 6 h.p. two-wheel tractor will pull a maximum of 450 lb. at working speeds (3). In practical terms this represents the mean draught of one plough body working 7″ deep and 11″ wide, on a dry sandy loam in Trinidad. There would not be sufficient power to cope with obstacles, or heavy patches of soil.

Other operations can be more satisfactorily handled, for instance :—

> The ploughing could be done without difficulty on a unique ploughing day, with the soil surface just dry (but the soil itself damp) and covered by very short, shallow-rooted grass ; a small two-gang disc harrow could be pulled in all but the hardest soil ; all ordinary scrapers and harrows could be pulled, but not in rice fields ; a two-row mechanical corn or cotton planter could be pulled.

It will be seen that although two oxen develop only about 1¼ horse-power at working speed, a tractor rated at 6 horse-power, in actual field practice, only does roughly the same work, and then only under favourable conditions. In a small tractor the difficulties of design for efficiency become very great, and it seems that maximum power transmission through the wheels could be achieved only at the expense of lightness, manoeuvrability and cost. That a six horse-power engine is capable of greater things was shown by a development at the National Institute of Agricultural Engineering. By means of a field anchor, a cable and tractor-mounted winch, a 6 h.p. tractor was able to pull 2,200 lb. and to plough (very deeply) one acre in 23 hours (4). This is less than the ploughing rate of a pair of oxen, but the plough was a very deep digger and the draught was far beyond the capability of a pair of oxen. Such a winching device might be workable in small rice fields in Trinidad.

Other important factors in the selection of small tractors for the tropics are : a low centre of gravity—especially if the machine is to work in hilly, deeply drained, or untidy country ; a handy reverse gear ; and, in a wet climate, fair weight on broad wheels of moderately large diameter so that the tractor will work with the minimum of wheel-slip losses.

The majority of British and American tractors are suitable for use overseas, but each in its proper work and suitable environment. A machine that can quite legitimately be called " general purpose " in a temperate agriculture may have only one use in a tropical country. Many small tractors were originally mechanical ploughs, and from that stage have developed into more versatile machines. In an agriculture in which ploughing either is not done, or is difficult owing to soil and climate, a tractor which has been designed around a plough may be less suitable than one which has originated in a rotary cultivator. Ploughing may not be the limiting factor to a farmer's productivity—the limit might be set by the area of land he can keep weeded during the wet season, or the area he can harvest. In such circumstances the rotary cultivator type of machine might be more suitable than the traction plough.

Modification of Machinery

Modification may be necessary to adapt an imported machine to local conditions. In Hawaii an American harvester-chopper-elevator was modified for use in Napier grass (5). Whereas the machine was useless when it was first tried, a few weeks of experimentation led to the saving of 4½ man hours on every ton of fodder cut and fed. Furthermore the chopped fodder was better utilized by the animals. In this particular instance the machine was large nd costly and was operated for a big herd of cattle—as witness the fact that three operators and at least $3,500 worth of machinery were occupied in this job.

Modification on a smaller scale is exemplified by the fitting of broad strakes, or cages, to tractor wheels for work in rice swamps, and it seems reasonable to suppose that after careful and systematic trial the tropical performance of many agricultural implements could be improved by local modification.

Modification of Techniques

The third principle is that an open mind should be preserved on the question of modification of agricultural techniques. Extreme caution must be preserved in altering a traditional technique to suit the machine, but we must be prepared to recognise that if mechanization is to come, change is likely to be necessary. As a local example it need only be noted that Trinidad rice fields are usually rectilinear. Therefore in order to be sufficiently level to retain water they must be small. If rice lands in new irrigation areas could be laid out in strips of uniform width, following the contour of the land, greater areas of water could be held up in single units. The fact of the strips being long would enable fairly large machines to work economically. The fact of their being curved along the contour would not matter so long as their width was fairly constant. In such fields, cultivation, sowing and harvester threshing could be done mechanically by big farmers or contractors, once a new local technique had been established.

Extension Services

Fourthly, in agricultural mechanization, extension (or advisory) work should proceed at least along with, and preferably in advance of, the mechanized front. Agricultural changes are usually slow, it is better for the stability of world farming that this is so ; mistakes are easily made and their effects on the land can be everlasting. Regard for a machine, like any other innovation, can only be built up by a slow painstaking process of practical demonstration and example. Not only are agrarians extremely individualistic, but there is likely to be a lack of mechanical knowledge on their part, and of agricultural knowledge on the part of machinery salesmen. The smaller agencies, may not have the time, the facilities, nor the liking for experimental work and machine modification. The machine operator, the farmer, the salesman and the agency proper could all benefit from, and contribute to, a sound advisory service. Unlike the sciences, very little research in agricultural mechanization can be done by individual investigators. The equipment for research, and the labour involved in doing it in the field, is expensive, and basic research in reality means little to the cultivator until its results have appeared in a machine. The information that is required must, therefore, be

collected from the field, from the factory, from the workshops, and must be made available to both the users and the suppliers of machinery. It must be a three-way traffic, in order that the potential user's requirements can be made known to Government departments, and to the trade.

This paper is mainly one of generalities. Generalities will not till the soil. An approach to mechanization has been suggested but there has been no mention of the implements which are available, their cost, the work they will do, and what they will save. These things are of immediate concern, but the answer is not known in the wet tropics, where there is so little agricultural machinery and experience is very limited. No agriculturist with a knowledge of machinery would care to predict a machine's performance unless he had seen it at work in similar conditions elsewhere. Until machines can be submitted to trial in commercial agriculture in the tropics, sound advice will be scanty.

Summary

Mechanization for the ordinary cultivator in the tropics is beset with difficulties not fully appreciated in the manufacturing countries. Most of the equipment in the tropics has been developed for use in conditions very different from those in which it is set to work. Many machines exist which would work well in the tropics, provided that—

(i) they were carefully selected ;

(ii) they were modified, when necessary, to cope with the generally harder conditions of the tropics ;

(iii) an open mind is kept on the question of changes in agricultural technique ; and

(iv) advisory services are ready to work, if possible, ahead of the wave of mechanization.

There is much to be said for close co-operation between the agriculturist, the agencies and the Government department ; to pool experience and to determine what machines should be imported for trial.

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FARM MECHANIZATION HANDBOOK

By P. A. Reynolds. *Temple Press Ltd., London,* 1948. *Pp.* 184. *Price* 8*s.* 6*d.*

Farm Mechanization Handbook is a very useful "farmers' textbook". Unlike the usual textbook on agricultural machinery, it deals in considerable detail with many practical aspects of machinery maintenance and operation. Field work is not considered, the object of the book being "to give a general working guide to the care and maintenance" of machines "on the modern farm".

There appears to be a slight lack of balance in the content of the Handbook especially as regards the degree of detail in which various sections are treated. It would appear that the author had carefully avoided topics which have been exhaustively dealt with elsewhere. There is no section, for instance, on ploughs. The bulk of the book deals with the international combustion engine and tractor components in a general, but very instructive, way. Nine cutaway drawings illustrate the working parts of representative tractor types.

In the tropics and in relatively undeveloped areas, farm mechanization implies something much wider than it does in, say, Britain. Equipment for water supply, irrigation, electrification ; produce handling and processing ; the forging, care, and use of simple tools—all these are of equal, if not greater, relative importance to the tropical agriculturist than the tractive unit itself. Farm Mechanization Handbook is not, therefore, so completely satisfying to the tropical reader as it probably is to the temperate, but would nevertheless be a good investment for any mechanized farmer, small machinery agent, or student of mechanized agriculture.

J.E.M.

BRITISH FARM MECHANIZATION

Monthly, 2*s. Temple Press Limited. London.*

Although an important purpose of this new periodical is to popularise British farm machinery in the world market it is not a trade journal. The broadest view is taken of mechanization ; the work of research departments is examined, new developments are announced, and manufacturers' production methods are described. An informative series of articles on Soil Conservation Practice has appeared as well as others dealing with specific aspects of mechanization. Other sections deal with the technicalities of maintenance and repair of specific machines. This is not a scientific journal, nor is it devoted only to commercial interests. It should, however, be of value to any agricultural department or institution, to all machinery agents and to many practical agriculturists. One gets a little tired, however, of the well-worn assertion that Britain's is the most highly mechanized agriculture in the world ; "tractors-per-square-yard" is a meaningless yardstick. It is printed on good paper and is attractively presented.—J.E.M.

MACHINERY ON THE FARM

By T. Hutchison. *Blackie & Son, Ltd., London and Glasgow*, 1949. *Pp.* VIII, 198. *Price:* 17*s.* 6*d.*

This book will be instructive to all who are particularly interested in agricultural machinery. The author treats of his subject in an appealing way. He has good historical perspective and an up-to-date approach to design trends.

The first reaction of the tropical agriculturist, however, will be of disappointment—not at what is written so much as at what is omitted. The imitations of the work are evident from the beginning, although the foreword (in which Lord Boyd Orr calls for parallel progress in mechanization and rural social amenities throughout the world to make the agricultural life as attractive as the urban) might have set the stage for a scene somewhat broader than that of domestic British—perhaps one might say, Scottish—farming. To the overseas reader it seems disproportionate that 17 per cent. of the text should be given to threshing machinery and only a like amount to power, which includes engines, tractors and electricity.

The author mentions four phases of mechanization ; the era of the ox, the horse-and-steam tillage period, the phase of oil-engine and tractor and the era of rubber. It must be remembered that in many countries agriculture is stepping directly from the first to the fourth stage and that many students of tropical agriculture may lack a basic conception, which the author has assumed, of how mechanization can fit into agriculture. "Machinery on the Farm" is, therefore—as, indeed, its title suggests—a useful description, and history, of the classes of machinery likely to be found on a British farm, written by a very experienced agricultural engineer and farmer. It is well illustrated and pleasantly bound. It is also rather expensive.—J.E.M.

FARM MACHINERY AND WORLD AGRICULTURE

Potential *v.* Actual Demand

The Editor of *British Farm Mechanization*, the new periodical referred to above, writes in Volume I, No. 7 (October, 1949) :—

> "The wide gap which exists between the potential demand for farm machinery and the actual demand is undoubtedly a menace to world prosperity. The potential demand for tractors and basic farm implements necessary to achieve maximum food production is the amount required to replace all draught animals and manual cultivation of the land. The actual demand is the amount of machinery for which farmers can afford to pay.
>
> "The idealists have as their objective the satisfying of the potential demand, and are undeterred by the fact that they are calling for the greatest revolution the world has known. Agricultural engineers have to face the present situation rather more realistically. It is a situation which has improved little from an international viewpoint since the time Jethro Tull walked behind his first grain drill, or when McCormick was unravelling the intricacies of mechanical sheaf-tying.

"It is true that since then, Britain, parts of North America and a few other corners of the earth have become what is extravagantly called "highly mechanized," but in comparing this area with the rest of the world's cultivable surface we are comparing the mouse with the elephant. This is a comparison which, however realistic to agricultural engineers and economists, has not yet been appreciated by politicians. "Cheap food and more food" is their cry, in a world in which farmers cannot afford machinery for higher production unless the price received for their produce is high in relation to the cost of mechanization. The farmer's profit is the predetermining influence on the actual demand for machinery ; increased acreages and yields are subsidiary to the net financial return.

"This monetary influence on food production and distribution could have been cut through by the Boyd Orr International Credit Plan, but it hardly seems to have been generally realised that dollar, pound or lira notes cannot make a breakfast.

"In the East, where there is the greatest gap between actual and potential demand destitution and hunger are to be found in their most malignant form. The rot is there too deep to be quickly cleansed. There is still time, however, for the West to realize the dangers and to take measures to resist the under-capitalization which is stultifying agricultural development.

"There is no doubt that progress in agricultural production lags seriously in most areas because of the lack of machinery. It is essential that the deadlock caused by potential but virtually ineffective demand should be broken and machinery should be allowed to flow freely into agricultural zones according to the needs of the primary producer. There need be no scarcity of machinery or scarcity of food if politicians and trade negotiators appreciated that the well-fed nation is a contented nation, and that a contented nation can add materially to the prosperity of the world.

"Industrial development and agricultural development are rivals in claims for financial credits in every country ; but, in our opinion, no doubt exists as to where priority should be given. Countries in a state of dire agricultural poverty are embarking on schemes of industrial expansion whilst the soil is still being scratched with a hoe. How long will it be before the truth is realised—that upon a nation's ability to feed itself rests its security and independence ?"

Tropical agriculturists will accept this view of a key to agricultural improvement with great reserve. The problem has been over-simplified. It is true that "progress in agricultural production lags seriously in most areas because of lack of machinery", but there is no reason to believe that machinery is lacking only because of the low purchasing power of the cultivator. It should be pointed out, too, that mechanization is only one of many factors that may be lacking. This is especially true in the tropics where mechanization may be of very secondary importance as compared with crop selection, the use of F.Y.M., and other basic means of improvement.

Peasant cultivators in general are incapable of using machines for reasons other than cost. For the most part they are incapable of using even their animals properly. Their standards of production and living can only be

lastingly improved by the play of economics and it is here that mechanization comes into perspective.

To pretend that a rise in food prices would bring machines to millions of peasants is to overlook the other, and more fundamental, side of the question—that industry evidently cannot provide cheaply the equipment, which would tempt the cultivator, reduce production costs, increase yields and improve the margin of profit.

The difficulties which would beset the agricultural engineering industry in doing this would be very great, especially in the tropics where machinery is subject to very hard usage, a difficult climate, high operating costs and poor repair facilities. Nevertheless, the industry has not really tried. The tropics and the "peasant countries" are offered machines which are cast-offs from a totally different, and highly developed agriculture. It must be acknowledged, however, that standardization of types is an essential in arriving at the low prices which are so necessary for the peasant.

The British agricultural machinery industry apparently cannot afford long-term market research, or even fundamental research, on its own account. The American industry has a big-machine market at home and is not interested in the lengthy business of building from nothing what at best could only be a small-machine market overseas. Yet the agricultural tools and machinery industry, more than any other engineering industry, controls the destinies of millions by the particular design, or the particular size, or the particular selling price of the particular machines it feels disposed to make for sale in the quickest market.—J.E.M.

ANIMAL AND PLANT BREEDING AND GENETICS

A SURVEY AND HISTORY OF DAIRY CATTLE OF TRINIDAD AND SUGGESTED POLICIES FOR THEIR IMPROVEMENT

BY

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THE dairy bovine of Trinidad is made up of mixed Bos indicus and Bos taurus blood, the proportion of Bos taurus generally preponderating. There are no fixed types and Holstein, Guernsey and Red Poll characteristics are present in some degree. Due to the greater use of Holstein blood in the last decade or so, most of the dairy cattle show particularly the characteristics of this breed.

The average dairy cow owned by peasants and small farmers in Trinidad presents a most dejected and 'unhappy' appearance. Both young and adult stock are stunted in growth, possess long staring coats, carry little flesh, and obviously suffer from malnutrition. External parasitic infestation (mainly ticks) is both heavy and common, while the incidence of internal parasites (tape worms, stomach worms and round worms, & etc.) is very high. The methods of husbandry practised are crude and unhygienic, there is a lack of knowledge and no application of balanced feeding, and it is very doubtful whether the production of milk is economically sound. In the opinion of the writer, if it were not for the sentiment and pride of ownership many fewer cattle would be kept.

These points of malnutrition, bad husbandry and the effects of parasites should and could be combated by education, demonstration and a better and more extensive veterinary service.

But even where cattle are subjected to improved husbandry it is noted that, though in better condition, they nevertheless suffer from certain disabilities such as high rates of respiration, high pulse rates, high body temperatures and there is a progressive deterioration both in performance and constitution in successive generations. It is quite evident that these cattle are not suited to the environment, which is a tropical one, warm and humid.

There were no bovines in the West Indies prior to the arrival of the Spanish colonists in the 15th and 16th centuries. These colonists brought cattle with them from Spain, Portugal and their West African Colonies. It is now known that the cattle of Spain and Portugal have a good proportion of African blood in them, e.g. the Raza Alentijana, Raza Minhota, Raza de Barroza and the Andalusian cattle. This African blood is considered to have been taken into the Iberian Peninsular during a migration of cattle of the Hamitic Longhorn type from Eastern Africa (Egypt) across the straits of Gibraltar about 2000 B.C. Another branch route of the migration was along the West Coast of Africa and as far South as the present French West African colonies, Liberia and Nigeria (1).

The Franqueiro breed in Brazil today was introduced from West Africa ; it is representative of the Hamitic Longhorn, and there are good grounds for believing that the original stock brought to Trinidad by the Spanish was similar to this breed, having a common origin. Such animals would be adapted to tropical conditions and would tolerate local conditions but in common with nearly all African cattle economic performance would not be high in comparison with European breeds.

It has been local policy to bring in such European breeds as Holstein, Jersey, Guernsey, Red Poll, etc. from Britain and North America in an attempt to combine by cross-breeding, the higher performance of the European breeds with the adaptability to the environment of the cattle whose ancestors originally came from Spain, Portugal and West Africa as mentioned above.

There is little doubt that the first generation of this crossbreeding presented a type, good in constitution and conformation, better in its behaviour to the tropical environment than its European parent, and better in performance than its local parent. Further crossing, if by Bos taurus would result in a decline of constitution, if by local blood in a decline in performance.

Cattle of the Mysore type of Bos indicus have been imported from time to time probably to " bolster up " by back-crossing the constitutions of the crossbreds and/or to provide better draught oxen than would result from the crossing of the Bos taurus and the original cattle.

Be that as it may, the result of these crossings has produced the heterogeneous mixture of animals which are to be seen in Trinidad today ; they are unstable in type and ill-adapted to prevailing conditions.

Experience shows that Bos taurus and high grades cannot perform well in tropical environments, due to tropical heat and humidity, except in high or specialised areas (e.g. Holsteins have been kept and maintained satisfactorily at Singapore, in air-conditioned buildings).

It is suggested that in Trinidad too much importance has been placed on the fetish of very high milk production. Instead of trying to produce cows which would give 800–1,000 gallons of milk a year better results might have resulted from a target of 500–600 gallons a year—which would fit in better with the lower nutritional value of pastures and the amount of fodder generally available.

The experience of Trinidad is not unique. The interbreeding of Bos taurus and Bos indicus has been tried in Tanganyika and the following remark in the 1944 Annual Report of the Veterinary Department of that Colony is of interest :—

> " The practice of grading-up local zebu cattle by the use of importeds bulls of European breeds is not likely to produce successful results of a permanent nature throughout the greater part of Tanganyika Territory though it is possible that with very careful management such stock might be maintained in a few selected areas provided the process is not carried too far."

Different breeds of animals, different systems of feeding and management, and different climatic conditions will obviously occur between Brazil, Texas, Louisiana, Jamaica, the Gold Coast, South Africa, Tanganyika, India, Queensland and the Philippine Islands, yet from these countries have come repeated statements that the grading up of local cattle with European bulls leads to constitutional failures (2).

As mentioned above the first generation of cross-breeds, owing to 'hybrid vigour', are generally of good conformation and constitution and are much better producers than their parents of the indigenous stock. It has sometimes been suggested that the continuous breeding of halfbreds for milk production would be justified.

Regarding this Wright (3) comments :—" There are two serious objections to such a policy :

(i) it would involve the maintenance of two purebred herds, one of European cattle and one of zebu cattle, in addition to the milking herd of halfbreds ;

(ii) in order to maintain milk production in the halfbreds they would need to be mated with a sire of one or other breed. But which breed ? And how would one dispose of the second generation progeny ?

The real problem in crossbreeding occurs, however, in generations subsequent to the halfbred. There are four alternatives :

(i) to mate continuously with European sires (so called " grading up "),

(ii) to mate continuously with sires of the indigenous breed (on the assumption that the single crossing with a European sire will have introduced once and for all the necessary milking potentialities),

(iii) to attempt to balance milk yield and constitution by the alternate use of European and zebu sires (so called " criss-crossing "), or

(iv) to mate crossbred with crossbred.

Continuous back-crossing to European sires (grading up) will, in a temperate climate, progressively raise the milk yield towards the level of the purebred stock. In a tropical climate the European sires will, however, also transmit those characters which prevent them from withstanding the rigours and hazards of their abnormal environment. The progeny will therefore fall off in constitution and will in the long run suffer from the same deterioration as purebred European cattle. Continuous back-crossing to indigenous sires will have the reverse effect : constitution will be progressively improved but potentialities for high milk production will be simultaneously reduced. Moreover the idea that a single crossing with a European sire is likely to introduce a " gene " for high milk production which will persist in all future generations fails to allow either for the multiple nature of the factors governing milk production or for the laws of probability.

The third alternative, criss-crossing, has been used in sheep-breeding (e.g. in the " comeback " type of sheep in Australia. It is important to note that " criss-crossing " with sheep was never claimed, or intended, to produce a single intermediate type), but has never been applied with success in the breeding of cattle suitable for the tropics .....it would entail the most careful control of breeding and considerable culling of unsuitable types and it would (as shown in sheep-breeding) in any event fail to produce the single " intermediate " type envisaged by its advocates. This method of breeding has already been attempted in Ceylon, for instance at the Government Dairy at

Colombo, where the original objective was to maintain stock with equal proportions of Ayrshire and Sindhi ancestry by using Ayrshire and Sindhi sires alternately. Latterly this policy has been altered in favour of using two Ayrshire crossings to each Sindhi crossing. The result is definitely *not* the production of a uniform type but of animals of very variable type, showing, it is true, some improvement in milk yield, but also showing degenerative changes in conformation and constitution.

The fourth alternative, mating crossbred with crossbred, is based on the mistaken impression that such stock will breed "true" and that the result will be an animal of intermediate type possessing the best characteristics of each of the original ancestors. The actual result of such an indiscriminate method of crossbreeding is almost inevitably the production of a heterogeneous population of cattle, varying unpredictably in yield, size, conformation and constitution and with no fixed characters. Attempts to achieve uniformity would involve repeated and wholesale culling with, in the end, little chance of "fixing" the desired qualities of the original purebred stock."

The policy which has been carried out in Trinidad for many years has been (*a*) the gradual 'grading up' by the use of European bulls on successive grades of heifers and cows and (*b*) indiscriminate mating of cross-breed by cross-breed. The progeny consists largely of unthrifty animals of almost a nondescript character. They have no similarity in type or conformation; their constitutions are generally poor and their economic potentialities are very limited. Even under the most favourable conditions of feeding, their heat regulating mechanisms are further upset due to the increased body heat which is derived from increased metabolic activity due to the increased food given them. It is obvious therefore that the whole practice of breeding requires rectification.

Two policies for improvement are suggested:

(1) The importation of some proved adaptable cattle, and

(2) An intense selective breeding of the animals which are now in Trinidad.

Of the two the former is to be preferred. Two Indian breeds, the Sahiwal or Montgomery and the Red Sindhi would be suitable; both have been highly selected for milk production; they are accustomed to a tropical environment with its heat and high humidity and show satisfactory tolerance to tropical epizoötic diseases. This policy is being tried in Tanganyika Territory and it has been reported on as follows:—(4)

"The inherent resistance of the Tanganyika lowland Zebu to tuberculosis, mastitis, streptothricosis, contagious vaginitis, &c., is a very valuable attribute which should be preserved as far as possible. With this point in mind we have been experimenting with the use of pedigree Zebu bulls of the Red Sindhi and Sahiwal breeds of India. Although the experiment is as yet in its initial stages and progress has been held up owing to the difficulty of replacing the stud bulls by fresh importations from India, nevertheless there is some evidence to show that the cross with our local native cows is a distinct improvement in both yield and conformation. Whether or not it will continue to thrive in the local environment is a question which cannot be answered at present."

The above remarks would not apply to the conditions we have in Trinidad because the Zebu in Tanganyika are of undiluted Zebu blood while the intense heterogeneity of the cattle here with which these imported breeds would have to be crossed would militate for a considerable number of years against the production of a fixed type. Unfortunately there is difficulty in obtaining either of these breeds from India—the authorities there show the greatest reluctance to exporting them.

Some Sahiwal cattle have been imported into Trinidad by the Department of Agriculture but it is believed that these Sahiwals were not of a good milking strain. They have however proved adaptable to the climatic conditions here, keep in good condition and do not show any deterioration.

The policy of intense selective breeding of suitable present types in Trinidad is the alternative method. It should be remembered that all the recognised European breeds have been evolved over a large number of years by a system of high selectivity and close breeding.

> On this subject Hagedoorn (5) states :—" The bad effects of in-breeding, being due to heterozygosity of the stock, are mainly due to cross-breeding in earlier generations. This is one of the paradoxes we meet in this subject. In-breeding produces variability and the production of undesirable individuals, but the only remedy is not out-crossing, which lays the foundation for much more impurity, but more and long-continued in-breeding.
>
> The use of in-breeding in selection makes it necessary to avoid the use of any but the very best breeding stock available.
>
> Breeders should never start in-breeding with a group of animals in which the best ones are not yet quite as good as they would like to see them. When in a variable group some animals are excellent, good enough for the purpose for which we keep them, then it is often possible to use in-breeding to great advantage with the object of making the majority of the animals pure for the inherited make-up of the exceptionally good foundation stock.
>
> There is always some danger when a breeder begins breeding-in that he gets discouraged by the production of many inferior individuals in the second or third generation. In the first generations the quality of the stock, measured as an average of everything born, may be below par. The thing to watch, however, in in-breeding during the first three or four generations is not the average quality but the quality of the best individuals, which must be used as breeding stock. During the first generations it will be necessary to discard a great number of animals, for it is really a matter of purifying the breed of unwanted material."
>
> Further, Nichols (6) states :—" When a superior individual has been found, in-breeding is the only method of keeping stock closely related to it. This holds good whether the desired characteristics are highly inherited or not. Genetic relationship cannot be more than 50 per cent. unless some in-breeding takes place. This situation can arise in the formative period of a breed when animals with the desired combination of traits are relatively rare ; for instance, the Colling brothers mated Favourite to his own daughters for four generations."

In the circumstances the writer advocates a policy of highly selective inbreeding of the very best types of dairy animals which can be obtained in the Island.

If it is found possible at a later stage to import stock from India of a proved dairy breed then it would be desirable as an "insurance policy" to test out experimentally the desirability of grading up the local mixed stock to such a breed

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BRITAIN CAN BREED IT

By the Farmer and Stockbreeder. *Dorset House, Stamford Street, London, S.E.* 1. *General Editor J. P. Goodwin*, 1949. *Pp.* 130

This book should prove most useful to teachers, students, farmers and livestock breeders, containing as it does nearly 70 excellent photogravure illustrations of most of the British breeds of cattle, pigs, horses and sheep. These illustrations show without exception the particular 'points' of each breed. In addition, there is a short history of each breed, its usefulness and to what parts of the world it has been exported.

The Right Honourable the Earl of Halifax, K.G., O.M., President of the Royal Agricultural Society of England, 1948, contributes a short foreword and there is a list of the different Breed Societies and their addresses.

The Volume is being distributed without charge direct to overseas breeders and others interested in Britain's stock.—G.W.H.W.

THE ELEMENTS OF GENETICS

By C. D. Darlington and K. Mather. *Allen and Unwin, London*, 1949. *Pp.* 446, *with* 1 *plate*, 88 *text figures*, 31 *tables*, 3 *appendices, and index. Price* 25*s.*

The science of cytogenetics is fifty years old ; it started as a small specialised limb of formal botany and zoology. Now, it may properly be regarded as the central biological science, a discipline that links and integrates all aspects of biology, that flows into chemistry and physics and begins profoundly to affect our understanding of man himself. In the course of such a remarkable outburst of learning, it is not surprising that there has been no one to stand back and see the whole field, to see the genetical implications of facts and researches not stated genetically. It is true, of course, that there have been many and excellent books written about certain aspects of the subject (though surprisingly few good elementary textbooks) ; but there has not, in the reviewer's knowledge, been any truly general book, one which would effectively represent a genetical understanding of biology as a whole.

This is what Darlington and Mather have attempted and, in great measure, they have succeeded. The compression of this vast subject into some 400 pages means that many conclusions are stated without the parallel statement of supporting (or conflicting) evidence and that many wide generalizations (some of them apparently new) are made with little or no critical discussion. This was unavoidable and the working cytogeneticist will recognise and treat these passages with the appropriate skepticism. It is otherwise with the cytogenetically naïve and here there is a real danger that fact may sometimes be confused with hypothesis. Furthermore, the approach is far from elementary, despite the title ; the necessary condensation demands that many steps in a critically important argument be shortened or omitted.

The cytogeneticist, then, will read with great profit—he will disagree with many statements and conclusions but even the process of disagreement will itself stimulate reflection. Others will read less profitably and, in the reviewer's opinion, the book could not and should not be used for elementary teaching.

The level of printing, production, illustration and tabulation is very high. References are well chosen without any attempt at exhaustiveness ; they are collected at the ends of chapters.—N.W.S.

SOVIET GENETICS AND WORLD SCIENCE

By Julian Huxley, M.A., D.Sc., F.R.S., *Chatto and Windus, London*, 1949. *Pp.* 245, *with bibliography and index. Price* 8*s.* 6*d.*

Official dogma has recently replaced the practice of genetical research in Russia. The process has been accompanied by violent controversy both in and out of the country of its origin and has been carefully documented in Britain and the United States of America, mainly in technical publications. Dr. Huxley is less concerned with the technical aspects (though these are, naturally, very ably expounded) than with the general social significance of the change. He proposes the thesis that the patent incorrectness of Lysenko's form of genetics is unimportant beside the real issue, that a state or government can proscribe a science on ideological grounds and enforce the adoption not only of wrong and internally inconsistent views but also of totally unscientific modes of research. The situation is not new—after all, the earth was once officially centre of the universe—but it is a sad comment on our times that it can happen again.

Dr. Huxley writes with his customary clarity and neatness and documents all the main points by cogent quotation. Some genetical technicalities cannot be avoided in such a book but these are set out simply enough so that the lay-reader, to whom the book is principally addressed, will encounter no great difficulty.—N.W.S.

BREEDING FOR DROUGHT RESISTANCE

By T. Ashton. Technique of Breeding for Drought Resistance in Crops. *Commonwealth Bureau of Plant Breeding and Genetics, Aberystwyth, Wales, Tech. Comm.* 14. *Pp.* 34, 1948. *Price* 2*s.* 6*d.*

This bulletin is a summary of published information on breeding or, more strictly, on testing for drought resistance. If a general conclusion is possible, it is that, while studies of anatomy, osmotic pressure, bound water, wilting tests and so forth may be useful in some cases as indices for selection, performance in the field in drought is the only certain criterion. The situation is complicated by the qualitatively and quantitatively different effects of drought at different stages of ontogeny.

About half the text is devoted to wheat and there are also substantial chapters on oats and grasses ; there is little information upon other crops and these are treated with appropriate brevity.

Plant breeders will be grateful to the author for bringing together a scattered literature (much of it Russian) ; and to the C.A.B. for good printing. —N.W.S.

A HANDBOOK OF TROPICAL AGRICULTURE

By G. B. Masefield, M.A., A.I.C.T.A. *Clarendon Press, Oxford* (*Geoffrey Cumberlege*). 1949. *Pp.* 182. *Price* 12*s.* 6*d.*

In a field so broad and so lacking in up-to-date standard works every authoritative contribution is welcome and of importance. This book deals very briefly with an enormous subject, and its title is probably a misnomer. A handbook is, or should be, a book of ready reference ; it should contain the maximum of factual information in the minimum of space. Here we have what must surely be the minimum of space, but the use of a very readable prose (rather than, say, tabulation and notes), precludes the cramming of detail into 182 pages. As an *introduction* to tropical agriculture it will be useful, especially to students and colonial administrators.

Since this book is (*a*) first in its class, and (*b*) obviously not intended for the specialist, it would not be difficult to point to omissions, but the author has dealt authoritatively with the principles of his subject and has supplemented his catalogue of crops with sections stressing the importance of soil conservation, and the increasing significance of animal husbandry in the tropics. A list of references following each section would have greatly increased the value of this work.—J.E.M.

A HISTORY OF ENGLISH FARMING

By C. S. Orwin, M.A., Litt.D. *Thomas Nelson Ltd., London,* 1949. *Pp.* 152. *Price* 8*s.* 6*d.*

This most readable little book is a welcome addition to the hitherto rather ponderous literature on agricultural history. In less than one hundred pages the author sketches the development of English farming from pre-historic times to the present day with a charm and adequacy that could only be achieved by an authority on the subject. The story is fascinating and it seems at first reading a pity that the essential facts of the lengthy last chapter reviewing the fortunes of the four partners in farming could not have been woven into " Farming in Competition " to the improvement of that chapter.

The book is attractively produced ; it contains numerous plate illustrations and a useful index. It should find its way into the libraries of agriculturist and townsman alike.—A.L.J.

" MANAGEMENT IN FARMING "

H.M.S.O., London, 1949 ; *Pp.* 68. *Price* 1*s.* 6*d.*

The title of this little book is misleading, being the name given by the National Agricultural Advisory Service, South Eastern Province, to a conference at which papers were presented by specialists in various aspects of agriculture. The book contains eight papers most of which deal with animal husbandry or the production of fodder. Professor Ashby's contribution is the one

exception, and he deals in a refreshing way with labour organization, economy in the use of mechanical appliances, and planning in management. As a brief synopsis of some recent trends in mixed farming in a temperate country these papers are very interesting.—J.E.M.

FIELD CROP ABSTRACTS

Vol. 1, *No.* 2 ; *Commonwealth Bureau of Pastures and Field Crops ; Aberystwyth, Wales. Bi-monthly, Price* 35*s. per annum.*

THE abstracts of the Commonwealth Agricultural Bureaux are well-known, and Field Crop Abstracts follows the general pattern. A wide range of subjects is covered, from Agricultural Engineering in the British Zone of Germany to Sowing on Stubble in Siberia and Pigment Glands of Cotton Seed. The section on News Items and Scientific Notes gives an interesting glimpse of current agricultural thought and events as reported in the press. Of the six annual issues, five will contain abstracts and the sixth the annual index. Field Crop Abstracts should be an important part of all scientific and agricultural reference libraries.—J.E.M.

SCIENTIFIC HORTICULTURE

VOL. IX, 1949. *Published for the Horticultural Education Association by Messrs. Jarrold & Son Ltd., The Empire Press, Norwich. Price* 10*s., with stiff cover, or* 7*s. with paper cover.*

THIS absorbingly interesting book of 175 pages is a collection of papers presented at the Revision Course in Horticulture (Midland Agricultural College, 1946) and at the Horticultural Education Association Conference (London 1947). Its purpose is to give progressive practical horticulturists in particular and all interested in agriculture in the wide sense of the term an authoritative summary of the advances made in various branches of horticulture during the last few years and particularly during the war and immediate post war years. The fact that each article is contributed by one of the leading British authorities on the subjects under discussion is sufficient assurance that the information presented is sound and well-balanced. The subjects covered include soils (soil surveys, organic matter, composts); soilless cultures; plant nutritional requirements (rapid tissue tests, plant injection methods) ; plant genetics, use of hormones, selective weed control, modern fungicides and insecticides, plant diseases, machinery and equipment, irrigation, certification schemes for growing plants. The fact that the papers have been incorporated in chronological order results in a somewhat disjointed arrangement of the contents, and although this does not result in difficulties in referring to the material on each individual subject owing to the generous use of foot notes, it would have been preferable to discard the chronological sequence in order to link up papers concerned with the same or allied subject in a logical arrangement. Although primarily addressed to horticulturists in Great Britain, the book has a wider appeal : the subjects discussed are of great interest to all interested in the growing of healthy crops and many of the methods described have found wide application in the tropics.—H.E.

PESTS AND DISEASES AND PLANT PROTECTION

SUPPLEMENTING BIOLOGICAL CONTROL

By

GEORGE N. WOLCOTT

(*Entomologist, Agricultural Experiment Station, University of Puerto Rico, Puerto Rico*)

The West Indian peach scale, *Pseudaulacaspis pentagona* (Targioni), would appear to have a most inappropriate common name. Although attacking papaya and numerous other tropical trees and shrubs, as well as introduced temperate zone mulberry and ash, it takes its name from the host which it destroyed so completely that peach trees now occur nowhere in the West Indian islands except in the highest mountains of Haiti. Not only are peach trees climatically unadaptable to the coastal and lowland areas of the West Indies, but mass attack by this scale, as on ash in Puerto Rico, promptly kills all trees that possibly otherwise might have survived. Even at elevations of over 4,000 feet, as at Kenscoff, Haiti, it often killed smaller branches and caused tip die-back, but because of exceptionally favourable climatic conditions, such as high humidity during most of the year, and often the possibility of irrigation during dry weather, peach trees usually survived the heaviest infestations that might develop. Indeed, the growers generally did not recognize the scale as a distinct entity, but referred to all growths on the bark of their trees as "lichens". To find peach trees actually producing fruit in the tropics came as a most delightful surprise to the higher officials of the American Occupation, and seemed to offer an opportunity for the Entomologist of Service Technique d'Agriculture to demonstrate the value of the recently developed machine oil sprays in the control of this scale (6). At that time Kenscoff was accessible only by trail, and the practical difficulties in conducting such a spraying campaign were matched by the technical inefficiency in scale control of the home-mixed oil spray of twenty years ago. After two years of strenuous effort, the project was discontinued, leaving the scale, after a very doubtful temporary set-back, in undisturbed control of the situation.

In subsequent years, no observation was made by any entomologist of its status on the peach trees of Kenscoff until 1946, when it was casually noted that the scale had disappeared. Incidental to another project, a somewhat more intensive survey in 1947 indicated no scale on any peach tree in the region, and a careful tree by tree examination in the spring of 1949 showed infestation on only three trees in the front yard of Chatelet des Fleurs, the lowest elevation at which peach trees are grown and irrigation is available. Because no observation was made during the critical period, definite proof is impossible of the single changed factor in its environment which temporarily at least eliminated peach scale from Kenscoff, yet a reconstruction from known elements presents the probable course of events.

When Atherton Lee came as Director to the Federal Agricultural Station at Mayaguez, Puerto Rico fresh from the Orient, he noted the insignificant use of bamboo locally, and thought that its use might be extended if the normally heavy infestation of the scale insect, *Asterolecanium bambusae* Boisduval, on *Bambusa vulgaris* were reduced. To this end he initiated the introduction of ladybeetles which might be predaceous on bamboo scales. In addition to those collected by Mr. S. M. Dohanian in Trinidad and British Guiana, and by Dr. K. A. Bartlett in South America, he noted "a few adults of the ladybeetle, *Chilocorus cacti* (L), feeding on the bamboo scale in Jamaica during March, 1937" (2, *see* pp. 100-102). At his request, Mr. H. K. Plank collected adults in Texas and Louisiana, and Mr. Angel R. Otero much greater numbers at Havana, Cuba, which were sent to Puerto Rico for breeding or release. *Chilocorus cacti* is a large, hemispherical ladybeetle, entirely shining black except for a large dark crimson spot on each elytron, and almost identical in gross appearance to the twice-stabbed ladybeetle, *Chilocorus bivulneris* Mulsant, which is more general in distribution in the United States and southern Canada. Previous to its introduction into Puerto Rico it was not known to occur in the West Indies outside of Cuba and Jamaica, but before 1944 it had arrived on Mona Island apparently without the aid of man (14), and was found in Hispaniola from La Romana at the eastern end, to Jeremie and Leogane towards the western end during the next few years.

The southern twice-stabbed ladybeetle found conditions in Puerto Rico most favourable for its multiplication, for it is most aggressive in rapid dispersion into all sorts of environments, not hesitating to devour many other kinds of scale insects besides those which are on bamboo. Had its arrival come at an earlier period, it might have rendered unnecessary much spraying in citrus groves. The most important factor limiting abundance is the omnipresence of arboreal lizards, especially *Anolis cristatellus* Duméril and Bibron, one of which occurs on practically every fence-post and sapling in coastal Puerto Rico and dozens of which live in every large tree. The naked, cylindrical trunk of a papaya offers no protection at all to a landing ladybeetle coming in search of scale insects to eat, and even when man releases a dozen or more ladybeetles at one time on a scale-infested tree, most of them are snapped up by the fearless lizard or lizards inhabiting that tree before the last one is out of the container. But if even one female survives to lay her eggs, her numerous progeny of less conspicuous, gregarious larvae tend to clean large areas of a papaya of scale insects. The ladybeetles are much more successful when protected by dense foliage from the watchful eye of the devouring lizards, and on the ornamental *Acalypha wilkesiana* have been noted locally exterminating large infestations of the same scale that they find so much difficulty in destroying on the trunk of the papaya : the West Indian peach scale, *Pseudaulacaspis pentagona* (Targioni).

During much of the year peach trees are as naked of foliage as the trunk of the papaya is of branches, and one might suppose that ladybeetles would experience as much difficulty in surviving on them. The one differing factor at Kenscoff is that the species of *Anolis* present are practically entirely terrestrial in their habits, and are not at all arboreal. Thus ladybeetles feeding on scale insects on peach trees were uninterrupted in their activities, and in fact were so successful, from the standpoint of the grower, that they entirely eliminated their food supply. The next generation was forced to

migrate, or perished of starvation in the Kenscoff region. This well illustrates the fundamental fallacy in biological control: when it is really successful it is so completely so that the predator is eliminated. With the aid of ever-watchful man, incipient outbreaks of the peach scale might now be eliminated, and commercial control become absolute local eradication. Without such interference, the only factor likely to prevent a recurrence of the heavy scale infestation is the aggressive migratory urge of the twice-stabbed ladybeetle, which still continues to exist at lower elevations elsewhere in Hispaniola.

On a much larger and economically more important scale, the same principle is being illustrated at the present time in Puerto Rico in the destructive outbreaks of white grubs, *Cnemarachis* (*Lachnosterna* or *Phyllophaga*) *portoricensis* (Smyth) and *C. vandinei* (Smyth), and of root-boring weevils, *Diaprepes abbreviatus* (Linnaeus), after so many years of absence that most cane-growers and other farmers are entirely unprepared to undertake their artificial control. These are native, endemic insects in Puerto Rico, and for that reason the prospect for the introduction of specific parasites from outside has always seemed doomed to failure. Indeed, the egg-clusters of *Diaprepes* are so heavily parasitized by *Tetrastichus haitiensis* Gahan during the months of May and June when most females oviposit, that survival depends on those exceptional individual female beetles which lay their eggs at other times of year when this common endemic egg-parasite is not in evidence (7). The number of species of Scoliid wasps attacking white grubs in Puerto Rico should be sufficient to control them under all local environments, yet they are so deficient in number of individuals that the effect of their presence is negligible (2). Introduction of foreign species of *Tiphia*, many years ago from Illinois, and most recently from Haiti, although a technical success in developing methods of collection, shipment and release (11), has been an absolute failure in establishment.

The key to control was not a single parasite, or an aggregate of specific parasites, but a predator potentially omnivorous but actually of such specialized feeding habits that it caught the adult beetles of these white grubs only during the very limited terrestrial periods of their existence. The giant Surinam toad, *Bufo marinus* (Linnaeus), largely subsists on ants in tropical South America (5), possibly because its presence renders impossible the development in any considerable numbers of anything comparable to May beetles. Because its introduction into Barbados and Jamaica was made so long ago, we have no record of the previous status of their May beetles, and can only estimate their importance when considering what a serious pest the Barbadian May beetle, *Phytalus smithi* Arrow, became when accidentally introduced into Mauritius (3).

The spectacular success of the introduced *Bufo marinus* in effecting commercial control of white grubs in the cane fields of Puerto Rico first became apparent at the time of the fourth congress of the International Society of Sugar Cane Technologists at San Juan in March, 1932 (4). Indeed, a rather considerable time interval had elapsed for the toad to become really abundant after the first introduction at Mayaguez in 1920 by Mr. D. W. May from Barbados, and that at Rio Piedras in 1922-23 by Mr. R. Menendez Ramos from Jamaica. But after its effectiveness was so definitely shown, introductions were made, beginning with Hawaii, that carried it around the world to every tropical locality where its food habits would indicate the possibility of its control of comparable insect pests. A few years later *Bufo marinus* reached

the peak of its abundance in Puerto Rico. What had at first seemed an unlimited food supply of May beetles (including what in Barbados are called "black hard-backs" as well as "brown hard-backs" and the smaller rhinoceros beetles), leaf beetles and millipedes became so scarce that what at first was only commercial control of white grubs in some fields eventually amounted to almost or total eradication in all the cane fields of the coastal areas.

Such a condition could not last indefinitely. It was the very end of the swing of the pendulum of the balance of nature. Ideal from the standpoint of the cane-growers, such perfect control of white grubs by eliminating the main food supply of the toad made the survival of any large number of them impossible. But this was not the only factor tending to limit their numbers. The predaceous Dytiscid beetle, *Megadytes giganteus* Castelnau, of which both the insatiable aquatic larvae as well as the adults feed on toad pollywogs, became noticeably abundant as compared with former scarcity in the years before such food have been available. Dragonfly nymphs and aquatic predaceous beetles and bugs also found toad tadpoles a desirable source of food, and had promptly taken advantage of such an exceptional opportunity. In addition to all other adverse factors however, a series of dry years caused the complete drying-up of both Guanica and Cartagena Lagoons, and of many other smaller ponds, pools and streams where the toad pollywogs might otherwise have developed (10). Such a combination of circumstances unfavourable to the toad made possible a rapid increase in the numbers of all insects, millipedes and other items of toad food which had come so near to extinction only a few years before.

The luminous click-beetle or "cucubano", *Pyrophorus luminosus* Illiger, which had continued to exist in the cooler mountainous areas of Puerto Rico, again has appeared in the humid coastal areas where it had been abundant before *Bufo marinus* had been brought to the Island. The millipedes, such as *Trigoniulus lumbricinus* (Gerstaecker) and *Orthomorpha coarctata* (Saussure), which had formed an important but little realized item of food for the toad, are again abundant after years of scarcity that coincide with those when the toads were most numerous. The smaller rhinoceros beetle, *Strataegus barbigerus* Chapin, was formerly a serious pest of young plant cane, especially in newly-cleared land, attacking the seed pieces before they had become well started. It had practically disappeared from Puerto Rico, and its specific parasite, the Scoliid wasp *Campsomeris atrata* (Fabricius), had never been seen during the year when the toad was in the ascendant, except on Mona Island in an environment undisturbed by the presence of the amphibian. Its grubs now appear in appreciable numbers mingled with ordinary white grubs. The most obvious effect of the scarcity of toads, however, is reflected in the outbreaks of white grubs in the cane fields of the south coast: outbreaks approaching in severity those which were normal in the years before *Bufo marinus* was brought to Puerto Rico. Such white grub outbreaks were possibly most numerous in 1948, but by 1949 the most injurious pest attacking cane roots was the "vaquita" grub of *Diaprepes abbreviatus* (Linnaeus).

The greatest difference between the losses suffered from the various kinds of soil-inhabiting grubs attacking the roots of sugar-cane before the introduction of *Bufo marinus* and those experienced now is that now such losses are largely unnecessary. Formerly no method of chemical control was commercially practical: today several effective chemicals are available,

and relatively enormous amounts of benzene hexachloride have been applied to cane fields in an attempt to kill the grubs. Laboratory tests indicate that two pounds of the gamma isomer per acre will effect commercial control, and its residual effect is apparently more lasting than of the equally effective Hyman 118. Even a few years ago, neither of these chemicals was commercially available, but that one of them should be extensively used now is symptomatic of the trend away from the uncertainty and lack of dependability of biological means to the use of chemicals entirely under the control of the grower. The most discouraging feature to the entomologist is that the growers rarely appreciate the benefits received from biological control, which cost them nothing in money or effort, and entirely lacks the sales pressure of the chemical insecticide companies to emphasize its value at the times when it was effective. The cash benefits obtained from the introduction of the Surinam toad from Barbados by Mr. D. W. May are unquestionably greater than of all the other activities of the Mayaguez Station, of which he was Director. He thought so little of it that no official notice of it was published until six years later, and even at that late date he did not mention its implications in control of white grubs. Yet the bottle-neck for Guanica Centrale before that time was the impossibility of growing enough cane on their heavily grub-infested lands in Puerto Rico to supply the needs of the new mill. This was the cause of the development at La Romana and the shipment from Santo Domingo of two or three boatloads of cane every week during the grinding season. Cane could not be ratooned on the south coast of Puerto Rico, and replanting was necessary for every crop. When control of white grubs had been effected in Puerto Rico by the toad, these mass shipments of cane from Santo Domingo could be discontinued without disorganizing the grinding season at Guanica. Fertilizer salesmen naturally claim some of the credit, but cane with its roots eaten away by white grubs cannot make use of fertilizer. Nor can improved and more heavily yielding varieties show their value when white grubs limit their possibilities. The presence of the toad enabled the cane to retain its roots and make the increased growth that kept the mill grinding, and all this at no cost to the grower. Inexpensive and effective for the many years that it lasted, biological control was definitely not under the control of man, and when it failed, the use of chemical insecticides became imperative to prevent losses until the toad might again regain its former numbers.

Despite its terrestrial and subterranean habits, the Puerto Rican mole-cricket or "changa", *Scapteriscus vicinus* Scudder, is much too lively to be easily caught by the toad, and normally forms a comparatively minor item of its food. Nevertheless, the toad unquestionably did reduce its numbers to some extent, as did also the introduction from Brazil of its specific parasite, *Larra americana* (Saussure), in the coastal sandy areas from Mayaguez to Humacao where plants of "botoncillo", *Borreria verticillata*, are abundant and the spherical button-like clusters of white flowers furnish nectar for the adult wasps (8). In the years of subnormal rainfall that proved so difficult for the toad to survive, the presence of the changa was less noticeable, as the mole-cricket burrows deep into the soil during times of drought. It appears at the surface only when heavy rains saturate the soil and force it to come up to avoid drowning. Thus when rainfall again became normal, the changas suddenly seemed enormously abundant as compared with the immediately

preceding years. Here again the synthesis of new insecticides made control possible, for although DDT merely keeps the changas out of treated areas temporarily, chlordan and Hyman 118 kill immediately, especially if their application is promptly followed by rain. By the next day, the surface of the soil will be covered with dead changas: the most convincing proof of the efficiency of these new insecticides.

In an analysis of these instances, it will be noted that the most apparent fundamental weakness of biological control was that it depended almost entirely upon but a single predator or parasite. The case of the cottony cushion scale, *Icerya purchasi* Maskell, in Puerto Rico is of quite a different character. The single important predator, which saved the citrus industry of California, when it was first brought from Australia, was the Vedalia ladybeetle, *Rodolia cardinalis* (Mulsant). To be sure, it was an important factor in control of the scale in Puerto Rico, but invariably supplemented by local parasites and predators, and never as completely effective on a large scale as the entomogenous fungus, *Spicaria javanica* Bally, under suitable conditions of continued high humidity (12). During the years of dispersion, the cottony cushion scale always managed to be in advance of the ladybeetle, but in ever lessening numbers until the final records in new localities were of single individuals or a single branch lightly infested (9). The small recurrent outbreaks in the regions where it had first become established were indeed quite as often controlled by local parasites and predators as by the ladybeetle which was thought to depend exclusively on it for food. In Puerto Rico, if Vedalia were to survive, it would have to eat something else than cottony cushion scale. This is in fact what did happen, for several recent records are of *Rodolia cardinalis* feeding on an endemic scale, *Icerya montserratensis* Riley and Howard. Other factors may be involved in what amounts to much better than merely commercial control of the cottony cushion scale, but the most obvious one is that several agencies of control continue to exist independently of their economic host, precariously it is true and in very small numbers, and possibly not very prompt in appearance when outbreaks start, yet any one of which may totally eliminate infestations. This constitutes really effective biological control, as nearly permanent as though *Icerya purchasi* were an endemic insect of which equilibrium at a low level of abundance had been secured in the distant past, rather than an introduced pest, in some countries capable of causing immense damage and even yet not controlled by its introduced parasites and predators.

This is by no means the only instance of native parasites attacking introduced pests, for the larva of the pink bollworm, *Pectinophora* (or *Platyedra*) *gossypiella* (Saunders), is parasitized in Puerto Rico by a small Bethylid wasp, *Perisierola* sp. nov., near *nigrifemur*, and by an Ichneumonid, *Calliephialtes ferrugineus* Cushman. Neither of these endemic wasps is at all abundant, and they are of negligible importance in control. Tens of thousands of individuals of three imported parasitic wasps which attack pink bollworm larvae elsewhere have been released in Puerto Rico, but none became established. The case for natural control of pink bollworm would seem to be hopeless, and the farmers generally are so indifferent to the carrying out of recommended cultural measures that infestation of the last bolls harvested is high. Of the insecticides previously available, none showed the slightest promise, and tests of the newer ones were made without anticipation of success. Rather unexpectedly, DDT

proves to be very much more effective in control of pink bollworm than any of the others, but the number of applications necessary is as yet undetermined.

The cotton leaf caterpillar, *Alabama argillacea* Hubner, has many natural enemies, but it normally occurs in such overwhelming numbers that they appear too late and in too small numbers to stop outbreaks. The second generation of parasites and predators is largely eluded by mass migration of the moths to other fields, sometimes near-by but often at such distances as to be in another island. state or country. Chlordan applied early will prevent oviposition by moths, and if put on after the appearance of the caterpillars will kill them much more promptly than arsenicals or DDT or any of the other of the newer chemicals. At last the cotton grower is able to protect his crop from insect injury by two major pests, and need not depend on the uncertain action of natural control.

If the success of biological control depends to such a large extent on the abundance of a single parasite or predator, the problem of maintenance during the periods of scarcity of its host may be serious. Herein lies at least one theoretical superiority of such semi-domesticated parasites as *Trichogramma minutum* Riley, which can be reared artificially in the laboratory. Let no one suppose, however, that total parasitism of the eggs of the sugar-cane moth borer, *Diatraea saccharalis* (Fabricius), can be obtained in the field when they are scarce. Five years of field observations in Puerto Rico indicate that below a certain level of abundance of moth borer eggs the little wasps experience as much difficulty in finding them as do the entomologists (13). Thus eventually considerable stalk injury develops, as was repeatedly demonstrated in the eastern part of the Island, despite the fact that at no time during the crop season was any stage of the borer noticeably abundant.

We may marvel at the ability of such a minute insect as *Trichogramma* in locating moth borer egg-clusters in the immensity of a cane field. Finding them is largely a matter of chance however, for the search is entirely unorganized, with the individual initiative of the female wasp very feeble a day after emergence if she fails in being able to relieve her internal egg-pressure or to obtain nourishment with the juices exuding from the punctured moth borer egg. Releases of laboratory-reared *Trichogramma* seem to be successful directly in proportion to the number of egg-clusters to be parasitized, and total parasitism, either natural or artificially induced, occurs only when egg-clusters are exceptionally abundant. Dispersion of *Trichogramma* is minimized during cold weather, so that releases in large fields of gran cultura or fall plant cane with many fresh egg-clusters are to be recommended to growers as invariably giving excellent results. On the contrary, during the summer in Puerto Rico artificial releases are quite superfluous, for these little wasps are so active that very rarely can a field be found with an abundance of egg-clusters of which the great majority have not already been parasitized.

It may seem simple enough to release artificially-reared parasites in the cane field, but that this has been rarely adopted in commercial practise indicates the difficulties in predicting or even determining the circumstances of an abundance of fresh, unparasitized egg-clusters under which it will surely be effective. Compared with the apparent simplicity of the application of a chemical insecticide, and the practical certainty of obtaining the anticipated results, those which may be obtained from biological control, either natural or artificial, invariably depend upon numerous other factors. Indeed it is most

fortunate that really effective chemical insecticides are now available for the control of so many insects to supplement the deficiencies and uncertainties of biological means when they fail to function. That chemical control of sugar-cane moth borer does not at present seem practical in the tropics is largely a matter of economics. Its short life-cycle and the long crop season during all of which the crop must be protected from attack involves many applications of any insecticide. Otherwise, the moth borer might be added to the list of pests of tropical crops for the control of which no other method than biological means was possible until these new chemicals were synthesized.

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(Received for publication, July, 1949)

MANUAL OF BACTERIAL PLANT DISEASES

By W. J. Dowson. *Adam L. Charles Black*, 1949. *Pp.* viii+183. *Price:* 16*s*.

A useful little book written primarily for the benefit of advanced students but far from being a 'comprehensive textbook' as it is somewhat euphemistically labelled on the dust cover.

The general approach to the subject in the introductory chapters of the book is good and students will find much solid general information on materials and methods in chapters III to VII. Considering the importance now attached to the Gram stain in the classification of bacteria, however, surprisingly little attention is devoted to the significance of the reaction.

Treatment of bacterial plant pathogens (Ch. VIII to XII, 91 pages) is very sketchy, especially the tropical ones ; Red Stripe of Sugar Cane (*Pseudomanas rubrilineans*) is dismissed in eight lines and the fact that *Pseudomonas solanacearum* can attack the banana is not even mentioned. The general description of *Xanthomonas Citri*, too, is misleading. The illustrations are mostly good and the distribution maps of the more important diseases useful. Printing and general layout are also good.—R.E.D.B.

BIOLOGY OF HUMAN PATHOGENIC FUNGI

(*Annales Cryptogamici et Phytopathologici, Vol. VI*) : *Edited by Walter J. Nickerson, Ph.D. Pp.* 236 + xx; *frontispiece*+50 *figs., comprising half-tone plates and illustrations*). *Waltham, Mass. : Chronica Botanica Co. London, W.C.* 2 : *Wm. Dawson & Sons Ltd.*, 1947. *Price* $5.00 (*U.S.*).

In this volume Dr. Nickerson has collected summaries by pioneers in different aspects of investigation into those comparatively little known fungi pathogenic to man. Scattered literature has been brought together, extricating what has so far been accomplished from a morass of nomenclatorial controversy. Emphasis is rightly laid on the need for fundamental research into the physiology of these pathogens, as a basis for the development of satisfactory therapeutic treatments. There are chapters devoted to the biology of specific fungi or groups of fungi associated with certain more important diseases ; others deal with the nutrition, respiration, and metabolism of the organisms, their reaction to antibiotics, &c.

Unfortunately, the presentation of the volume as a compilation of separate contributions leads to a lack of cohesion. A more concise and readable account, embodying the material available, could have been produced by fewer authors, working in closer collaboration.—W.T.D.

METEOROLOGICAL DATA

IMPERIAL COLLEGE OF TROPICAL AGRICULTURE METEOROLOGICAL STATION

MEAN VALUES FOR 21 YEARS (1929–1949)

Month	Total Rainfall (ins.)	No. of Rainy Days	Sunshine (hours) per day	Daily Maximum Temperature (°F)	Daily Minimum Temperature (°F)	Daily Minimum Relative Humidity (per cent.)
January ...	2.83	16	7.6	84	68	57
February ...	1.32	11	8.2	85	67	52
March ...	1.30	21	8.0	86	68	51
April ...	1.91	10	8.1	87	71	52
May ...	5.03	16	7.8	88	72	57
June ...	8.56	22	6.7	86	72	63
July ...	8.58	23	7.2	86	72	63
August ...	9.83	23	6.9	87	71	63
September ...	7.85	19	6.5	87	72	62
October ...	6.37	17	7.0	87	72	62
November ...	7.80	28	7.0	86	71	63
December ...	6.41	20	7.1	85	70	62
Mean Value ...	5.65 per month	19 per month	7.4 per day	86	70.5	59
Mean Annual Rainfall ...	67.79					

COMMUNICATIONS ON ORIGINAL INVESTIGATIONS

EXPERIMENTS WITH MAMEY FOR PESTS OF MAN AND ANIMALS

By

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Author's Summary

The gummy sap that abounds in the thick rind and developing seeds of the half-ripe fruits of mamey (*Mammea americana* L.) was demonstrated to be useful in the control of two common pests of domestic animals and man. This sap occurs naturally as an emulsion and soon coagulates on exposure to air, but it readily diffused when the half-ripe fruits were thinly sliced or grated in water. When used against fleas and ticks on dogs, an infusion of 1 lb. of such fruit in water to make 1 gal. was as effective but not so permanent as a 1-per cent. suspension of DDT.

Introduction

The control of external parasites on domestic animals, particularly in the Tropics, has always been a serious problem. In many localities where no control measures are practised cattle are frequently so heavily infested with ticks as to have an unnatural color and be unable to gain weight or produce milk. Other animals become almost as heavily infested with fleas and lice as well as ticks and mites. Some of these pests also attack man. On pets, such as cats and dogs, they endanger human health because of their ability to spread internal parasites and disease.

Various materials have been used effectively to control these pests. Among the commonest of such insecticides are powdered Derris root and DDT, either alone or in combination, for ticks and lice (3, p. 150 ; 9, p. 12) and various forms of derris, pyrethrum, and DDT for fleas (1, p. 13 ; 3, p. 414). In many parts of the Tropics, however, these materials are not always available. Under such conditions, many farmers resort to what might be called home remedies. Most of these remedies usually employ various parts of certain indigenous plants in their preparation.

History of Mamey

In the West Indies and nearby regions of South America, one of the oldest remedies for many animal pests, and particularly for chigo fleas ("miguas") that attack man, is the gummy resin present in various parts of the mamey tree (*Mammea americana* L.) (2, pp. 82-83). Considered to be indigenous to the West Indies, this tree also grows in many other parts of the American Tropics and is successfully cultivated as far north as southern Florida (7, pp. 401-403) (*See* fig. 1). In Ecuador the sap is used for killing chigos and lice, a decoction

Fig. 1.—Mamey tree (*Mammea americana*) in bearing. Some trees in Puerto Rico are known to produce from 300 to 400 fruits in 2 crops per year. Half-ripe fruits and the seeds from mature fruits yield a gummy sap that is useful in the control of certain insects.

FIG. 2.—Half-ripe mamey fruits in proper condition to make a water infusion for use as an insecticide. Note greenish-yellow sap, which contains the insecticidally active principle, oozing from small cells in the thick rind and developing seeds of the cut fruits in foreground. In this condition, the seed coat is still soft enough not to interfere with slicing or grating of the entire fruit, and the gummy sap readily mixes with water. (About ½ natural size)

of the seed for mange and sheep ticks, and a cerate for many kinds of insects (10). In Cuba, where the tree is known as "Mamey de Santo Domingo," a decoction of the bark is used for external parasites of animals and for eczema (8, p. 443).

In Puerto Rico, mamey demonstrated to be toxic to a number of common insects that infest plants as well as some of those that infest animals (5, pp. 737-738 : 6, p. 13). Different parts of the mamey tree were dried and tested in the laboratory as finely ground powders. The seeds of the mature fruit were found to be more effective as an insecticide than any other part of the plant, and the powder made from them was successfully used against fleas and ticks on dogs and fleas on cats. Chemical analysis showed that toxicity was due to a type of substance somewhat similar to the pyrethrins contained in pyrethrum flowers (4).

A preliminary trial was made of the immature fruit in the manner recorded by Grosourdy and said to be sometimes employed locally by small farmers, namely as an infusion in water (2, p. 82). Such an infusion was rather easily made by thinly slicing or grating the immature to half-ripe fruits in water at the rate of 1 lb. of fruit (1 medium sized fruit) to the gallon. The greenish-yellow, gummy sap which abounds in the developing seeds and thick rind of such fruits contains the insecticidally active principle (*see* fig. 2). This sap occurs naturally as an emulsion. When fresh it readily disperses in water, but when exposed to the air it coagulates and soon becomes immiscible with water. To prevent coagulation and to obtain the maximum amount of dispersed sap it was necessary to keep the cut surface of the fruit wet by frequent immersion in the water during preparation. The resulting mixture was allowed to steep at room temperature for about 18 hours and then strained through a cloth to remove particles of fruit pulp. A yellowish-brown solution resulted which darkened and fermented somewhat on standing but which retained its ability to kill insects for nearly a month. The gummy sap gradually settled to the bottom but did not coagulate appreciably for several weeks and could easily be redispersed by agitation. This infusion, like the powdered seeds, was found also to be highly toxic to fleas and ticks (6, p. 13).

Mamey Compared with DDT

Both the powdered seeds and the water infusion of the half-ripe fruits of mamey were tested in comparison with DDT. Medium-sized short-haired dogs were used that were heavily infested with fleas, mostly cat fleas (*Ctenocephalides felis* Bouché). In addition, two of these dogs carried light infestations of the brown dog tick (*Rhipicephalus sanguineus* (Latr.)).

In the first experiment, three dogs, of which one was infested with ticks, were dusted liberally with the powdered seeds, using about 15 grams per dog and rubbing it well into the hair. Another lot of three dogs, one tick-infested, was bathed in the immature-fruit infusion prepared as described above. A third lot of three dogs was bathed in a water suspension containing 1 per cent. of DDT by weight. This latter bath was prepared by thoroughly mixing with each gallon of water 75.7 grams of a commercial wettable powder containing 50 per cent. of DDT and especially made for use on livestock. It took about half pint of each bath per dog to wet the hair thoroughly. No effort was made to keep any of these materials from getting into the eyes or mouth of the dogs.

Within 24 hours after treatment all dogs were free of fleas, and on one of the dogs treated with the infusion of half-ripe mamey fruits 17 out of 18 ticks were also dead. In 3 more days all ticks were dead on this dog and also on the one that had been treated with mamey-seed dust. No reinfestation took place during 11 days of confinement to untreated quarters, but all dogs, including those that had been treated with DDT, became reinfested with fleas and one of the mamey-bathed dogs with a few ticks also within 1 week after being liberated.

In a second experiment the infusion of mamey fruit and DDT, both prepared as before, were used to bathe two lots of three dogs each. All dogs were heavily infested with fleas and in addition one dog in each lot was moderately infested with ticks. One of the dogs treated with the mamey-fruit infusion had received the same treatment a month previously and the other two had been dusted with the powdered seeds. Two of the dogs treated with DDT had previously received this treatment and one had been treated with the powdered mamey seeds. In this experiment the same amount of materia was used as formerly, and again no effort was made to keep either bath from the eyes or mouth of any of the animals.

Immediately after treatment the fleas on both lots of dogs became very active and moved toward the outside portions of the hair, but the majority of fleas were at least partially paralyzed in 15 minutes. Most of those treated with the mamey infusion were dead in this length of time, but a few showed signs of life at the end of half an hour. DDT, on the other hand, did not appear to act so quickly ; most of the fleas under this treatment dropped from their hosts in this time, and many were still alive though unable to move normally. All fleas and ticks under both treatments were dead at the end of 5 hours.

The dogs in this second experiment were liberated 6 hours after treatment. One of the mamey-treated animals became reinfested with fleas in 3 days and the remainder within a week. One of the dogs treated with DDT became reinfested in 6 days, another in 7 days, and the third in 13 days. None of the dogs in either lot became reinfested with ticks during 2 weeks after treatment.

One or more dogs in both experiments had healing sores or minor abrasions on the skin. Although none of the dogs treated with mamey was observed to lick itself after treatment, two of those treated with DDT did so on numerous occasions. In spite of this, neither treatment appeared at any time to have any deleterious effect on the health or behaviour of any of the animals.

The mamey-fruit infusion and seed dust tended to color the coat of the white haired dogs to a light brownish yellow, whereas the DDT suspension gave the darker dogs a grayish-white appearance. However, neither discoloration was objectionable, and both gradually disappeared until they were hardly noticeable at the end of 2 weeks.

In the foregoing tests, mamey, either as powdered mature seeds or a water infusion of the half-ripe fruits, was as effective but not quite so permanent as a 1-per cent. suspension of DDT in the control of fleas and ticks on dogs.

Its long-standing record of usefulness and the foregoing demonstration of its effectiveness make mamey a good material for combating some common pests of domestic animals and man. The water-infusion method described offers an inexpensive and readily available means of control in many parts of the American Tropics.

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VASCULAR WILT DISEASE OF THE OIL PALM

CAUSED BY *Fusarium Oxysporum* Schl.

By

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Author's Summary

An account is given of the occurrence, distribution and symptoms of a vascular wilt disease of the oil palm in West and Central Africa, caused by *Fusarium oxysporum* Schl.

1. *Introduction*

During a visit to the Belgian Congo in 1946 I observed a wilt disease of the oil palm (*Elaeis guineensis*), and isolated *Fusarium oxysporum* from necrosed vascular strands (Wardlaw, 1946, 1946*a*, 1946*b*). In 1947, Messrs. S. de Blank and F. Ferguson, in a private report, announced the presence of this disease in Nigeria and submitted cultures to me for identification; and in 1948 I was able to confirm their diagnosis during a visit to the affected plantations (Wardlaw, 1948, 1948*a*). Substantial proof of the pathogenicity of *F. oxysporum* is now being obtained by workers in the Belgian Congo. This disease is already of considerable practical importance. It is of still greater potential importance and as it may occur in regions other than those indicated above the following illustrated report has been prepared in the general interest.

2. *Occurrence and Distribution*

Vascular wilt disease has been observed in plantations and natural palmeries from Calabar to Benin in Nigeria and from Brabanta on the Kasai in the southern Congo to Yangambi on the main river in the north; i.e., it has already a wide distribution. Accordingly, although the first notification of this "new" disease was given in 1946, there can be no doubt, by analogy with the vascular wilt disease of bananas, that it is of long standing in West and Central Africa.

Under plantation conditions, infected palms may occur singly, in small groups, or in more considerable clumps. In occasional instances considerable areas, e.g., whole plantation blocks may be severely affected. Blocks have been observed in which 20 per cent. of the palms planted in 1936 have been destroyed. The disease may also be observed in nursery plants of 18 months, or in casual seedlings in plantations. The disease may become conspicuous and exemplify the characteristic symptoms of a vascular wilt disease in palms of from 4 to 14 or more years of age.

Fig. 1—A typical case of vascular wilt disease in a 12-year-old oil palm.

FIG. 2—Longitudinal median section of the base of a trunk, showing the conspicuous basal fissure and the associated necrosed vascular strands ; some of the latter can be seen in the central tissue well above the basal fissure.

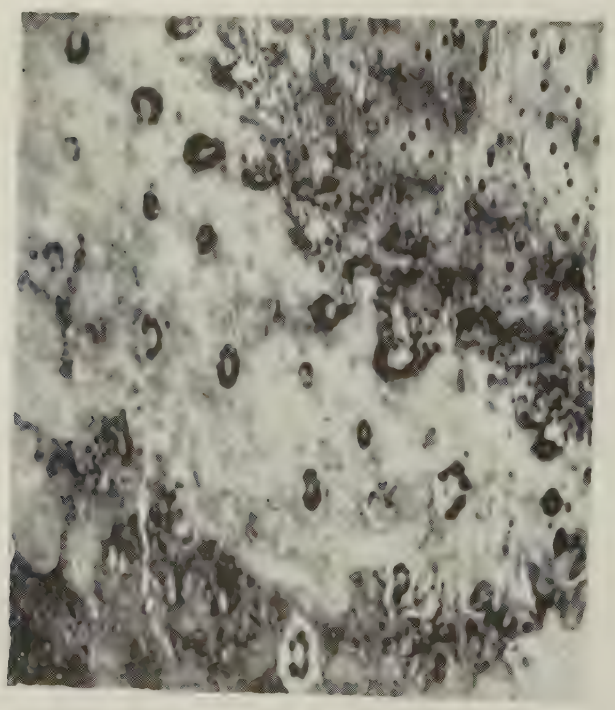

FIG. 3.—Tangential section through the base of an infected trunk. Numerous diseased roots traverse the cortex (left and below) while the highly necrosed vascular strands of the trunk can be seen in evident continuity (top right).

3. *External Symptoms*

It will be convenient, by way of introduction, to describe the external symptoms as they may be observed in severely affected palms of 7-12 years of age. Fuller investigations are awaited, but already there is evidence that the pathogenic fungus is soil-borne and penetrates the host by way of the roots and through wounds at the base of the trunk. When the infection has reached a critical stage, the leaves, previously erect or semi-erect, green and healthy, develop typical symptoms of wilting. They bend downwards, have a flagging appearance, break near the leaf base, or some distance above it, and hang down round the trunk in a cluster Fig. 1. This wilting and breaking may proceed quickly so that, in the course of a few months, a palm which formerly had a full crown may be left with only a few leaves. These, too, break down and eventually the palm dies. In some palms, wilting and petiole breaking first become apparent in the lower, older leaves, these effects spreading upwards towards the crown. In others, where, as inspection has shown, the disease is unevenly distributed in the trunk, the sequence of leaf wilting may be rather irregular, e.g., two or three younger leaves, above the lowermost cycle of old leaves, may alone show wilting in the early manifestation of external symptoms; or occasional leaves or groups of leaves scattered through the crown may be affected. This irregular distribution of wilting leaves was at first rather puzzling; but where dissections of the trunk were made, an asymmetrical distribution of infected vascular strands was usually found.

According to environmental conditions and other factors still insufficiently investigated, more or less marked leaf discolouration may accompany wilting. Leaves may show a pronounced yellow colouration, sometimes even a conspicuous lemon yellow colour. This colour usually develops first in the distal pinnae and spreads backwards towards the leaf base. In some areas, e.g., in certain Nigerian plantations, the leaf symptoms are conspicuous but variable and present different aspects at different seasons. Leaves which show conspicuous yellow colour at the end of the rains become less conspicuous as the dry season advances, some of the older leaves becoming desiccated and brown. According to their position in the crown, and depending on the age of the palm, these brown leaves may remain rigid and erect, or they may break and hang down in various characteristic ways. By contrast with palms showing evident symptoms, there are others in which the wilted leaves remain more or less green.

As to the causes underlying this diversity of symptoms everything has yet to be discovered : for the time being, the following possibly relevant aspects may be indicated : (*a*) the age of the palm at the time of the initial infection; (*b*) environmental factors (soil and climate); (*c*) the susceptibility of palms of different genetical constitution.

A Critical Note on Chlorosis and Wilt Symptoms—Investigations of diseased oil palms have shown me how little confidence can be placed in external symptoms alone in the diagnosis of disease. The chlorotic condition of leaves, for example, may be found in palms suffering from vascular wilt disease, Armillaria trunk rot, other fungal diseases, and adverse conditions of growth, while wilt symptoms, affecting some, or eventually all, of the leaves, are typical of palms suffering from vascular wilt disease, Armillaria trunk rot,

Ganoderma trunk rot, bud rot, &c. Again, the stripped and rigid condition of the outer leaves of typical Plant Failure cases (Wardlaw, 1946) can also be seen in young palms severely affected by vascular wilt disease. For an assured diagnosis an examination of the internal symptoms and the isolation of the pathogen are necessary. But once the diagnosis has been made in any particular plantation, a majority of palms showing certain external symptoms may with a high degree of assurance be referred to a particular disease.

4. *Internal Symptoms*

Dissections of trunks of wilted palms have shown that the disease is located in the vascular system, the wood vessels, as in the vascular wilt disease of bananas, being the seat of fungal activity. Fig. 2. shows evidence of dark necrosed vascular strands round the large basal fissure which is to be seen in most plantation palms. The infected vascular strands may be central, peripheral or both.

Root symptoms consist of the presence of necrotic brown or red streaks in the vascular system in close proximity to the trunk. This is undoubtedly one of the routes by which the infection of the trunk takes place. But even in severely affected palms, a majority of the main spreading roots may be quite healthy. Immediately below the base of the trunk, however, diseased roots will usually be encountered in considerable numbers. In some instances necrotic streaks may be seen in the vascular strand of the main spreading roots some distance away from the trunk. (A severe rot of the cortical tissues of roots (sometimes accompanied by vascular symptoms) has on occasions been encountered. This is probably due to attack by another soil micro-organism). The destruction of roots by the pathogen is a contributory but not the sole cause of the wilted condition of the leaves. Fig. 3, a tangential section of the base of a diseased palm, shows numerous necrosed roots in cross-section in the trunk cortex, and strongly necrosed vascular strands of the trunk.

The pathogen spreads upwards in the trunk by way of the wood vessels. Affected strands turn a brownish grey colour and then become almost black, in contrast to the pale yellow or ivory colour of healthy strands. Diseased strands are usually most abundant towards the periphery of the trunk, but, as the disease advances, the more centrally situated strands become affected. Eventually dark strands can be seen in the crown and passing out into the leaf bases, Fig. 4. The presence of the pathogen may cause an abnormal darkening of the fibrous region of the vascular strands in advance of the actual necrosis of the wood vessels.

Anatomical Details—Fungal filaments can readily be observed in the necrosed wood vessels in microscopic sections. Bacteria were not observed in the wood vessels. The presence of the fungus causes a profuse exudation of gum so that the vessels become blocked, with concomitant reduction of water supply to the leaves. This is one factor in the eventual development of wilt symptoms. Tyloses are formed and these also cause a blockage of vessels. These several points have been described in some detail and illustrated by Kovachich (1948), working in my laboratory, on materials collected in the Belgian Congo. The anatomical details are closely parallel to those which have been observed in the vascular strands of wilted bananas.

Fig. 4.—Longitudinal median section of the upper region of the trunk of a 12-year-old palm, showing the highly necrosed condition of the vascular strands close to the apical growing point.

FIG. 5.—Vascular wilt disease in seedling palms in longitudinal median section.

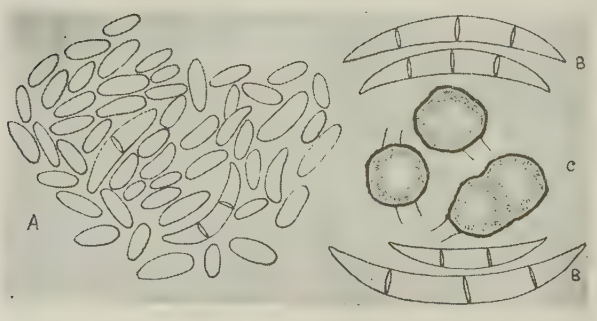

FIG. 6.—Conidia of *Fusarium oxysporum* as grown on a standard synthetic cultured medium (drawn by Dr. T. Gogoi).

Critical Note on Black Streaking—The internal black streaking in trunks of diseased palms is an important subject and one on which our information is still inadequate. For the benefit of those who may undertake a fuller investigation of the several trunk diseases, this brief note on different types of black streaking may be of value.

In a healthy palm the vascular strands are of a pale ivory colour though there may be departures from this, e.g., buff, pink, or orange colour may be observed in the vascular strands in some trunks. In vascular wilt disease, the characteristic streaking consists in the development of necrotic rusty brown or brownish-black colour *in the wood-vessels*; some darkening of the fibre which lies external to the phloem also takes place. In old palms severely attacked by *Ganoderma* sp. black streaking is also present but this is due to a *darkening of the fibre*, though lower down in the trunk the vessels may be discoloured by a dark gum. In Armillaria trunk rot, dark streaks may occur in proximity to the regions of mass decay ; here also the dark colour is located in the fibre. In some old palms, 20 years of age or more, which are apparently not diseased, black colour in the fibre may be observed extending some distance up the trunk ; in other palms, of the same age and growing in proximity, no such darkening of the fibre is to be seen. In general, some darkening both of the fibre and wood vessels is present in proximity to wounded regions. In young palms, black streaks are almost invariably found in proximity to the basal fissure. Some of these streaks may extend some distance upwards into the trunk; others may remain localised near the fissure. In different instances these black streaks are due to darkening of the fibre, to the effect of wounding or exposure on the wood vessels, and to the inroads of the fungus of vascular wilt disease and other micro-organisms.

5. *Disease in Seedlings*

Palm seedlings observed in some Nigerian nurseries were unthrifty in appearance, with desiccated, brown, outer leaves and inner leaves showing yellow and dingy yellow colours, &c. Some, but by no means all, of these plants were found to have necrosed vascular strands, these being evident well up into the shoot in some specimens, Fig. 5. This observation is important because it indicates that seedling plants are subject to vascular wilt disease while there is the further possibility that palms already infected may from time to time have been transferred from the nursery to the field. No constant relationship could be established between the external symptoms indicated above and the presence of streaking within. The fact that susceptible seedlings may show early infection should tend to shorten the time required for carrying out mycological tests in relation to the breeding of resistant strains. It has now been established that *Fusarium oxysporum* is present in the necrosed vascular tissue in seedlings (Wardlaw, 1948); cultures of the pathogen have been obtained from nursery and casual plantation seedlings 18 months old and upwards. (Other seedling diseases are also known to occur).

6. *Isolation of Fungi*

Both in the Belgian Congo and Nigeria, *Fusarium oxysporum* Schl., Fig. 6, has been isolated with a high degree of consistency from the necrosed vascular strands of typical cases of vascular wilt disease and from seedling infections.

Substantial confirmation of the pathogenicity of this organism is beginning to be obtained. The morphology, growth and colour reactions of the fungus on a standard synthetic medium have been described by Gogoi (1949) and an account of a considerable number of isolations, from infected palms in West and Central Africa will be published in a later number of this Journal.

Cultural Characters—On a standard synthetic medium (glucose, 2gm; potato starch, 50gm; sodium nitrate, 2gm; tripotassium phosphate, 1.25gm; magnesium sulphate, 0.75gm; agar, 15gm; water, 1,000 ml.) the following characters were observed after two weeks at 25°C: luxuriant aerial mycelium; indigo blue colour in medium extending from near centre to periphery of culture; microconidia, approximately 90 per cent., $3.0 \times 1.5\mu$, macroconidia, approximately 10 per cent., some 3-septate and rather straight, but higher septations also present, $13.5 \times 3.0 - 33.0 \times 4.5\mu$; both micro- and macro-conidia directly abstricted; chlamydospores abundant, $4.5 - 9.0\mu$ diam; sclerotia present later in some isolations. In some isolations macro-conidia were more abundant; in others they were almost completely absent. On rice pink to crimson colouration developed. Fuller details are given by Gogoi (1949).

When attempts were made to isolate fungus in culture from necrosed vessels (*a*) high up in the trunk and (*b*) near the base, the former quickly and consistently yielded cultures of *Fusarium oxysporum* whereas the latter, in many instances, yielded no culture or slowly developing cultures after a considerable number of days. This brief record may be interesting and suggestive to those who may undertake further mycological studies: it is scarcely to be expected that hyphae will still be alive near the trunk-base in old infected palms.

7. *Varietal Susceptibility*

By analogy with the vascular wilt disease of bananas, where the susceptibility or resistance of different varieties and hybrids is now well known, it is a reasonable assumption that the oil palm, which both in plantations and natural palmeries is represented by a genetically heterogenous population, will also show varietal susceptibility. Already there is evidence of this phenomenon, for some palms in a plantation are susceptible from the seedling stage onwards to a leaf disease known as Patch Yellow, whereas others are not. The fungus associated with this disease is a strain of *Fusarium oxysporum* (Wardlaw, 1946). This strain, however, differs in its cultural and morphological characters from that isolated from infected vascular strands (Gogoi, 1949). Although the conidia of the Patch Yellow strain of *F. oxysporum* are constantly being disseminated through plantations, only certain palms ever show the infection. Immediately adjacent palms even after twenty years still show none of the characteristic leaf symptoms. Here, then, is one instance of varietal susceptibility to a pathogenic strain of *F. oxysporum*. Accordingly, as a working hypothesis, it may well be supposed that, in the palm population at large, both resistant and susceptible varieties are present; and in any breeding programme there should therefore be a search not only for improved oil productivity, desirable vegetative characters and environmental adaptation but also for resistance to vascular wilt disease. The importance of this aspect can scarcely be over-emphasised. Vascular wilt disease may not be the most important disease of oil palms in West and Central Africa at the present

time, but, by analogy with the destruction wrought by *Fusarium oxysporum cubense* on the Gros Michel banana, it is potentially the most dangerous cause of loss to the oil palm industry in the future. Selection and breeding of disease-resistant varieties is the only method in sight at the present time that can have an economic application under African plantation conditions. The need for (i) an intensive scientific investigation of the disease, (ii) an interim programme of selecting planting stock for use during the next 5-10 years, and (iii) a full scale genetical programme in which the aim will be to combine good fruiting characters and environmental adaptation with disease resistance, should be duly stressed.

8. *Disease Complex in Palms*

Not the least of the difficulties of this investigation was the fact that many of the unthrifty-looking palms in the poorer areas were found to be suffering from a complex of diseases (Wardlaw, 1946). Thus vascular wilt disease has been observed in conjunction with Armillaria trunk rot, with other trunk rots and lesions not yet diagnosed, and with deficiency diseases collectively described as Plant Failure. All this has made the diagnosis and assessment of wilt disease matters of some difficulty, while external symptoms alone proved highly deceptive. But, as investigations progress, these matters will be sorted out and a clearer picture of the several diseases with their special and distinctive features will in due course be obtained.

9. *Acknowledgment.*

I should like to place on record my thanks to Messrs. The United Africa Company, London, for making possible my visits to the Belgian Congo and Nigeria in 1946 and 1948, and my very great indebtedness to Messrs. S. de Blank, G. G. Watterson, the late F. Ferguson and W. G. Kovachich for their unstinted help and collaboration in the field studies recorded here.

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RESULTS OF SOME EXPERIMENTS ON THE PRESERVATION OF CACAO SEED IN VIABLE CONDITION

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Author's Summary

Experiments on the storage of cocoa pods and of cocoa beans under tropical conditions have shown that the important factors involved in storage are free access of air and a low rate of water loss. These conditions have been achieved by storage in finely powdered charcoal of relatively low moisture content. Cocoa beans have been successfully established as seedlings after 13 weeks storage in perforated tins in charcoal of 30–35 per cent. moisture per cent. dry weight.

Introduction

Experiments on the storage of cacao seed were carried out by Pyke (1934) and by Pyke, Leonard and Wardlaw (1934). These experiments were confined to the storage of seed in the pod and included results on the influence of storage temperature on viability of seed from stored pods. It was concluded that the factors involved in deterioration of pods under normal conditions were desiccation, fungal decay and senescence. In cool storage there was a temperature below which rapid lethal effects of chilling appeared. The higher limit of this lethal temperature range was approximately 50 °F.

The optimum storage temperature was 60 °F. : at this temperature germination remained perfect for 40-50 days.

It is very seldom, however, that it is possible to arrange for a maintained temperature of 60 °F. for the transport of cacao seed. The existence of a relatively high lethal temperature for cacao seed is of considerable importance in that such temperatures are frequently encountered within the tropics in the unheated cargo compartments of aircraft during flight at relatively high altitudes.

Pyke (1934) rightly emphasized the fact that the cocoa bean is a non-resting seed in that it is ready for germination when the fruit is ripe and normally loses its capacity to germinate after a comparatively short period of storage. It was probably for this reason that attention was almost exclusively directed to the proper conditions for the storage of the pod rather than to the storage of the individual seeds since the condition inside the pod would be expected to be more near the optimum requirements.

In view of the poor results which were obtained in recent years in the transport of cacao seed from Trinidad to other regions in the Tropics, it was considered desirable to carry out further investigations on the storage of cacao seed and in particular to attempt suitable methods of storage and transport under tropical conditions. The experiments described in the present report were carried out with this object in view. They were extended to cover storage of the isolated seeds as well as of the pod.

I—Pod Storage Experiments

No information was previously available on the influence of the age of the pod (or rather of various degrees of maturity of the pod) on germination and storage behaviour under tropical conditions.

Pods of three categories were collected (*a*) fully ripe pods in which the beans were loose in the pod (*b*) almost mature pods as shown by the colour development of the pod but in which the beans could only be moved slightly even by vigorous shaking of the pod and (*c*) under-ripe pods which had reached full size but did not show ripening colour changes and in which the beans were held in a still relatively hard pulp.

Notes were taken of the existence of any fungal blemishes on the pods before placing in storage.

Pods of each category were smeared with vaseline and wrapped in waxed paper and untreated controls were wrapped in tissue paper. Pods were stored in perforated galvanized iron containers which were left on the laboratory bench for the duration of the experiment.

Samples were taken for germination counts after 10 days, 20 days and 30 days storage periods. Initial germination counts of samples of the same material showed almost 100% germination (168 established from 170 seeds) for all three categories of seeds. Germination was more rapid in the under-ripe pods (category C)—bulges made in the sand medium as a result of the opening of the cotyledons were seen several days earlier in this category of seed than in the more mature seeds.

The percentage of successfully germinated and established seedlings for the three categories of pods after the stated periods of storage are given in Table I.

TABLE I. (*Percentage germination of seeds from pods of varying degrees of maturity*)

	Period of Storage		
	10 days	20 days	30 days
	Per cent.	Per cent.	Per cent.
Category A. Fully ripe	73	50	17
Category B. Almost fully ripe	73	60	2
Category C. Under-ripe	0	24*	23*
Category A. Not vaselined	100	40	—

* All from one pod.

It is seen that the viability of the under-ripe seeds falls rapidly : curiously, however, one pod of this category showed a high germination count in the 20-day and 30-day samples, the remaining ten pods giving no germination at all. Germination of all the categories fell rapidly after 20 days and there had been an appreciable drop in the percentage germination even of the ripe pods in ten days.

Unvaselined pods, however, showed 100 per cent. germination at 10 days and still gave 40 per cent. germination at 20 days even though the pod was hard and shrivelled.

The results of this experiment showed that whereas the vaseline and waxed paper greatly reduced water loss from the pod the treatment appeared to exert a deleterious effect on subsequent germination of the seed.

It is logical to assume that the beneficial effect of the vaseline treatment would lie in the reduced water loss from the pod whilst its deleterious effect would result from the impeded gaseous exchange.

A further experiment was carried out with pods given the following treatments :—

1. Untreated.
2. Vaselined only.
3. Cavity of pod filled with sterile water under aseptic conditions.
4. Cavity of pod filled with sterile water aseptically and pod then vaselined.

The pods were left on the laboratory bench for 16 days.

Germination counts and final establishment of the seedlings were made for each treatment. There were no viable seeds in either treatment which involved vaselining the pods. The untreated pods showed 42 per cent. germination in spite of being badly shrivelled whilst the pod injected with sterile water gave 60 per cent. germination. These experiments indicated that the best conditions for storage of the pods would be found in such treatments as would combine restricted water loss with free gaseous exchange. It is obvious that any treatment which involves waterproofing the pod against water loss would impede gaseous exchange and thus be unsatisfactory.

In order to achieve this object an experiment was carried out in which untreated pods were stored in well packed powdered charcoal. Full treatments were as follows :—

The category of definitely under-ripe pod was not used in view of the rapid fall in viability demonstrated in the previous experiments—the two categories of pods used were fully ripe (Category A) and almost fully ripe (Category B). Pods of the two categories were stored in (I) air-dry unsterilized charcoal powder (II) steam sterilized charcoal powder of high moisture content. Free access of air was allowed in both cases by perforations in the storage tins. Samples were taken for germination counts after 18 days, 25 days, 32 days and 42 days after placing in storage. The percentage germination and final establishment are given in Table II.

TABLE II. (*Effect of Maturity and Moisture Content of Charcoal on Germination of Seed*)

Period of Storage	Air-dry charcoal		Moist steam sterilized charcoal	
	Category A	Category B	Category A	Category B
	Per cent.	Per cent.	Per cent.	Per cent.
18 days	61	40	100	100
25 days	0	93	33	67
32 days	0	98	100	100
42 days	0	0	100	100

Where no germination was obtained or the germination was very low, the pods had been attacked by pathogenic organisms and had turned brown.

Where the pods remained free from blemish—germination was excellent even after six weeks storage. Destruction of pods by pathogenic organisms is considerably higher in the dry charcoal : storage in moist charcoal by maintaining full turgor in the pod walls materially reduces rotting of the pod. Free access of air is an essential requirement—storage in charcoal powder in airtight tins leads to a rapid fall in percentage germination rate.

Attempts to slow down the maturation rate without reducing the viability of the seeds by treatment of the pods with naphthalene acetic acid were unsuccessful. Percentage germination of the seed from treated pods fell more rapidly than that of seed from untreated pods.

II—Experiments on the Storage of Seed

In view of the fact that there are some risks of introduction of disease involved in the importation of pods and that many agricultural departments prefer to import viable beans removed from the pod, a parallel series of experiments were carried out on the storage of cocao beans. A large scale experiment was carried out involving the following treatments :—

(1) Seeds with attached pulp layered in moist charcoal in airtight containers.

(2) Similar to treatment (1) but with free access of air through numerous perforations in the walls of the containers.

(3) Seeds with testas removed placed in sterilized moist charcoal in airtight containers.

(4) Seeds with pulp immersed in a solution of 10 p.p.m. naphthalene acetic acid. Much of the pulp removed by manipulating the beans gently through the hands whilst submerged in the solution. Planted in moist charcoal in sealed containers without previous rinsing.

(5) Pulp removed by manipulating beans in a thick suspension of powdered charcoal in water but testas left intact. Seeds soaked in 1 per cent. calcium hypochlorite solution rinsed in sterile water and planted in sterilized charcoal with access of air.

(6) Similar to treatment (5) but neither seeds nor charcoal sterilized.

Samples of seeds from each of these treatments were taken for planting after periods of storage of 10 days, 20 days and 33 days.

Results

After 10 days storage there were considerable differences in the stage of development occasioned mainly by availability of oxygen. In those treatments in which air was excluded (apart from that already present in the containers) the radicle had emerged to the extent of 1/16 to 1/8 inch, whereas in the treatments in which oxygen was available the radicle had reached a length of 2 inches. Germination tests gave 100 per cent. germination from all the treatments after 10 days storage.

After 20 days storage, differences in the appearance of the seedlings were quite marked. The greatest differences were between those which had free access of air and those in sealed containers. In the former the beans had developed into good stout seedlings with a branched root system, thick hypocotyl and partly unfolded cotyledons. The degree of development in the sealed containers was least in treatment (1) where the fermenting pulp

must have depleted the oxygen supply faster than in those where the pulp was first removed. The radicles had not progressed beyond the original development of 1/16″-1/8″ and the tips of the radicles were showing a brown discolouration. In other sealed containers the radicle had attained a length of ½″-1″ but many showed necrosis of the root tip.

The percentage germination (or rather the percentage establishment) in the case of those seeds with access of air was 100 per cent. but was nil in treatment (1) and only 20 per cent. in treatments (3) and (4).

After 33 days storage about 60 per cent. of the seeds in treatments (1), (3) and (4) were rotted, the remainder showed browning of the radicle tip—no plants were established from these treatments. Young seedlings in treatments (2), (5) and (6) although showing considerable contortions of the hypocotyl were in good condition and were successfully established.

The results of this experiment confirmed those described above for pods in establishing the necessity of free access of air if the viability of the cacao seed is to be maintained. No clear cut effect of the hormone treatment could be established. Removal of pulp was of slight benefit in the absence of a free air supply but was of no importance when air had access to the seeds.

Having established these facts a further experiment was carried out to compare the effect of different moisture contents of the charcoal powder in combination with different air supplies. Three levels of moisture content were used :

(1) Charcoal powder containing as much water as it will hold after draining—high moisture charcoal.
(2) Charcoal powder of medium moisture content prepared by mixing equal parts of (1) with air-dry charcoal—medium moisture charcoal.
(3) Charcoal powder of low moisture content prepared by mixing 10 per cent. of (1) with 90 per cent. of air-dry charcoal.

The samples taken for the exact determination of moisture content at the beginning of the experiment were accidentally lost. Samples taken at the end of the experiment showed 51.2 per cent., 43 per cent., and 30 per cent. moisture respectively in the three levels of moisture.*

The original moisture content would, of course, be added to by the moisture contained in the pulp of the beans.

The containers used were empty tennis ball tins—two tins to each unit. The two tins were filled separately and by removal of the metal collar from one component the two tins could be fixed together and gave a good seal.

Holes were made with a 1½″ nail in the tins as follows :—

(i) One hole at the end of each tin.
(ii) One hole at the end of each tin plus 4 holes spaced at equal intervals in the sides of the tins.
(iii) Three holes at the end of each tin.
(iv) Three holes at the end of each tin plus eight holes spaced at equal intervals along the sides of the tins.

The three levels of moisture content of the charcoal were used in combination with these treatments.

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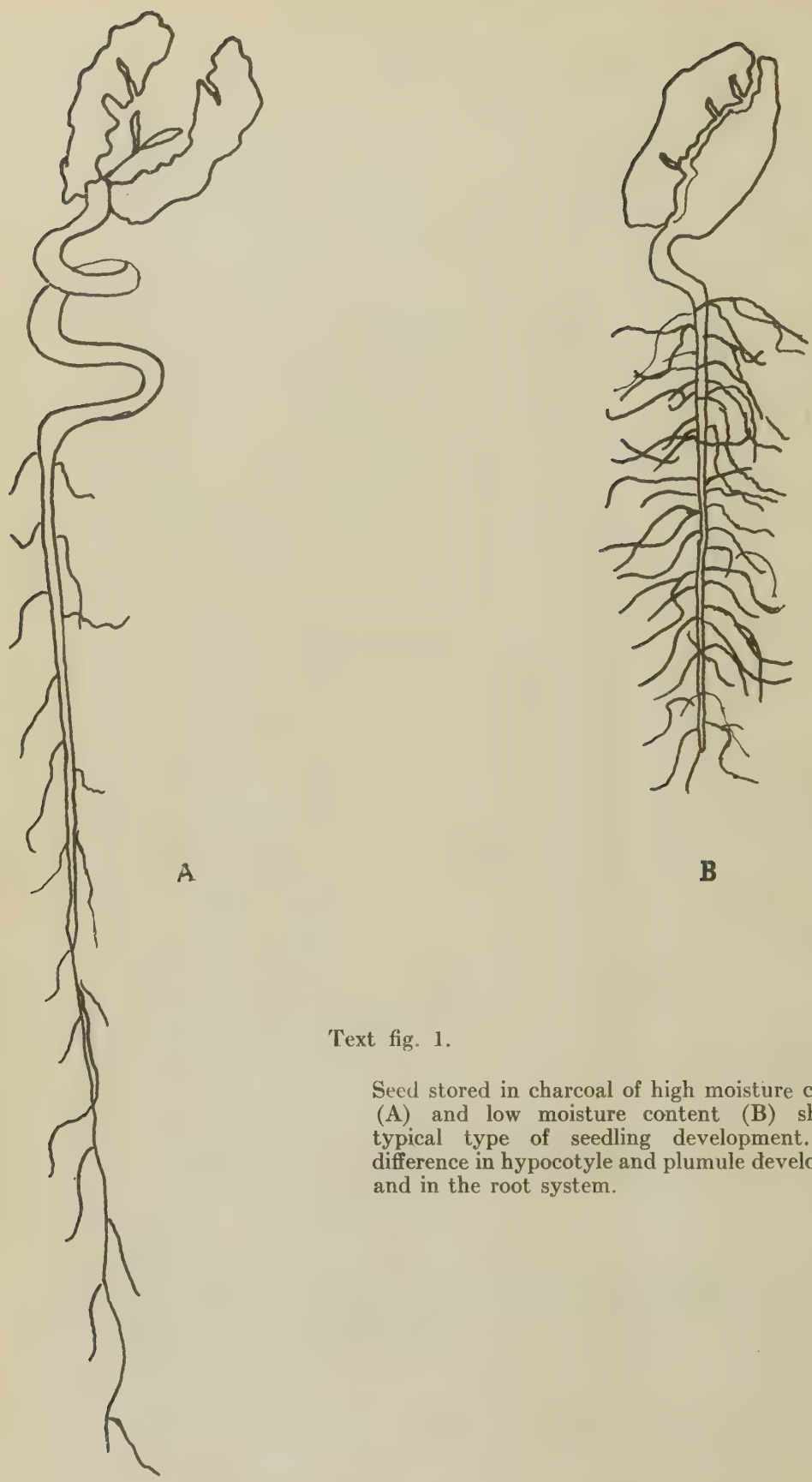
* Further work on the optimum moisture content of the charcoal within narrower limits than those used here is envisaged as soon as adequate quantities of beans become available : also on the seed storage behaviour of different clones. All this work refers to open pollinated beans of the clone ICS I.



Text fig. 1.

Seed stored in charcoal of high moisture content (A) and low moisture content (B) showing typical type of seedling development. Note difference in hypocotyle and plumule development and in the root system.

Owing to the narrowness of the tins it was impossible to orientate the seeds and they were therefore dropped in, six seeds to each layer with 1-1½ inches of charcoal between each layer of seed. Each individual treatment was duplicated.

Seeds were removed from the first set after 9 weeks storage in the laboratory at tropical temperatures : the second set was opened after 13 weeks.

The type of development which occurred was markedly affected by the moisture content of the charcoal (*see* Text fig. 1) and to a lesser extent by the number of holes in the container.

In the high moisture series, the radicle had grown to a considerable length and had relatively few branch roots, the hypocotyl development was particularly pronounced and in forcing its way in the compact space the turgid hypocotyl had snapped in many instances. There was no improvement in the appearance of the seedlings with increasing air-supply. In particular, the number of plants with snapped hypocotyls was substantially greater and as a result attack by pathogenic organisms was more marked in the containers with the greater air supply. It was apparent that the conditions had been too favourable for rapid growth which in the confined space was not desirable. The appearance of the plants in the lowest moisture level of the charcoal was quite different from those in the moist charcoal. Development was largely confined to the root system—the main tap root was not as long as in the high moisture series but bore a profusion of branch roots. The hypocotyl showed the minimum development and the cotyledons had not unfolded. The hypocotyl although short was somewhat coiled but did not show the contortions of the high moisture series, nor were there any cases where the hypocotyl had snapped.

In the intermediate moisture series the plants approximated more closely to the high moisture series than to the low moisture series. Here, however, the appearance of the seedlings improved with increasing air supply, there being fewer cases of snapped hypocotyls. This was probably due to water loss through the air holes which brought the moisture content of the charcoal down more rapidly.

Removal of the seedlings from the narrow tins used in the experiment caused considerable difficulty in the high moisture series, but was accomplished relatively easy in the low moisture series by sharply tapping the inverted container. After nine weeks storage almost 100 per cent. establishment was obtained from the seedlings in the charcoal of lowest moisture level and in the medium moisture level with high air supply. The percentage establishment was considerably lower in the high moisture series.

After 13 weeks storage the appearance of the seedlings was not appreciably different from their appearance at 9 weeks but the superiority of the low moisture charcoal was evident, many of the seedlings in the high moisture series having rotted. Some 70 per cent. of the plants were successfully established and the number would probably have been greater if more suitable treatment had been given the plants after potting out.

In particular, care must be taken not to over-water the young seedlings as they are more prone to attack by plant pathogens after long storage.

It is unlikely that a period of storage of 13 weeks will actually be necessary in practice but it is interesting to note that viable seedlings may be obtained after this lengthy period of storage with the right conditions of moisture and ogygen supply.

Before the results of this experiment were known, experimental shipments of cacao seed were made to Kew Gardens. One lot was despatched by air and included the following treatments :

(1) Pods—wrapped in waxed paper.

(2) Pods—smeared with vaseline and wrapped in waxed paper.

(3) Seeds—layered in moist charcoal in a tennis-ball tin.

All boxes were well lagged with wood straw to reduce any chances of chilling at high altitudes.

Germination was 96 per cent. in the pod merely wrapped in waxed paper, 12 per cent. in the vaselined pods and 81 per cent. in the seeds layered in charcoal. Another lot was sent by ship as seeds in moist charcoal. Owing to delay in leaving Trinidad over 5 weeks elapsed before this lot could be planted at Kew. 80 per cent. of the seedlings were alive on arrival but with the high moisture content of the charcoal difficulty was experienced in removing the seedlings and some suffered damage. Those which were not damaged were successfully established. Had the results of the experiments on the effect of varying the moisture content of the charcoal been available there is little doubt that the development of the seedlings could have been more closely controlled.

It is interesting to note that seedlings which were planted out after 9 weeks and 13 weeks storage developed quite normally. Contortions of the hypocotyl, which were minimal in the series stored in the drier charcoal, give an unattractive appearance to the seedlings in the early stages. In the potting out stage it is possible to bury the twisted base of the stem and the seedling thereafter is straight and indistinguishable from normal unstored seedlings.

Conclusions

1. If pods are to be transported to arrive at their destination within 14 days or so, good germination is obtained merely by wrapping the pod in tissue or waxed paper. If despatched by air the pods should be well lagged against temporary exposure to chilling temperatures. Water-proofing, such as by smearing with vaseline significantly decreases the viability of the seed.

2. If pods are to be transported to arrive at their destination in 6 weeks to 2 months healthy unblemished pods should be packed in moist finely ground charcoal in perforated containers allowing free access of air. The pods should be in such a stage of ripeness that the beans move slightly in the pod when the latter is shaken.

3. Cocoa beans may be despatched to arrive at their destination in viable condition providing that they are given conditions which allow a limited development of the seedling. Difficulties arise if the rate of development of the seedling is too rapid.

4. The correct conditions involve placing ripe seeds with pulp attached in relatively dry charcoal powder (moisture content approximately 30 per cent. and in any case not exceeding 35 per cent.) in containers in which air is made accessible by perforations in the sides and/or ends.

5. Under these conditions development of the seedling is largely confined to root development with very restricted growth of the hypocotyl and no elongation of the plumule. The cotyledons open normally and the plumule elongates when the seedlings are planted out.

6. If the moisture content of the charcoal is high rapid growth and thickening of the hypocotyl takes place as well as opening of the cotyledons and elongation of the plumule. The turgid hypocotyl becomes spirally contorted and often snaps. It is, therefore, highly essential to control the type of seedling development to encourage greater root growth and less hypocotyl and plumule growth. This is achieved by utilizing the storage conditions indicated in para. 4 above.

7. Cocoa beans have been stored for a period of 13 weeks in the laboratory under tropical conditions and the seedlings successfully established.

8. It is probable that this relatively simple technique may be found useful for the seeds of other tropical plants where the period of viability is short particularly tea seed and possibly coffee amongst others. In the former case prior treatment of the seed-coat to increase its permeability to carbon dioxide would possibly be necessary before packing the seed in charcoal. Adequate techniques are available for this purpose.

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THE FEEDING OF DAIRY CATTLE IN BARBADOS

PART I. THE FEEDING VALUE OF SOME TROPICAL FODDERS (WITH NOTES)

By

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AUTHOR'S SUMMARY

1. A table giving the nutritive value of local and imported fodders and silages is presented.
2. In the discussion of this table which follows, three main points were made : (*a*) Lower content of Digestible Crude Protein of these fodders when compared with figures for grazing land in the United Kingdom ; (*b*) The high dry matter content of these fodders generally, and of sour grass and cane tops especially ; (*c*) The wide nutritive ratio of these fodders.
3. Reference is made to preliminary observations of work in Barbados where it has been found under certain conditions to be possible to feed the locally grown fodders for the maintenance ration of dairy cows, in conjunction with a protein rich concentrate having a narrow nutritive ratio.

Introduction

As a preliminary to experimental work on the feeding of dairy cattle in Barbados it was necessary to collect together the results of fodder analyses carried out in the Barbados Government Laboratory during the past eight years. These analyses relate to local pasture and fodder crops and varieties of fodder crops and legumes imported for experimental purposes.

TABLE I. *Nutritive Values of Fodders*

Fodder	D.M.	S.E.	D.C.P.	N.R.
	%	%	%	
Sugar cane fodder (26 weeks old)	25.8	14.9	0.45	1 : 34
Sugar cane fodder (13 weeks old)	25.1	15.2	0.68	1 : 22
Sugar cane fodder (6½ weeks old)	24.5	13.4	0.84	1 : 16
Elephant grass (26 weeks old)	27.8	13.4	0.71	1 : 19
(*Pennisetum purpureum*) (13 weeks old) ...	21.9	11.5	0.71	1 : 18
(*Pennisetum purpureum*) (6½ weeks old) ...	18.6	9.2	0.96	1 : 9
Var. Merker (13 weeks old) ...	22.5	12.2	1.28	1 : 9
Var. Uganda (13 weeks old) ...	22.5	12.4	0.78	1 : 15
Var. Florida (13 weeks old) ...	28.8	15.5	1.51	1 : 9
Guatemala grass (26 weeks old) ...	27.0	13.7	0.55	1 : 25
(*Tripsacum laxum*) (13 weeks old) ...	24.4	12.2	0.54	1 : 22
(*Tripsacum laxum*) (6½ weeks old) ...	21.1	10.6	0.73	1 : 15
Sour grass *Andropogon pertusus* (and *A. nodosus*)				
Mean analysis for wet season	47.2	24.7	1.35	1 : 17
Mean analysis for dry season	71.9	36.6	1.27	1 : 28
Sour grass—legume mixture (wet season) natural	47.2	23.9	1.9	1 : 12
Sour grass and *Clitoria ternata*, (*Teramnus labialis* *Rhyncosia mixima.*)	37.2	19.1	1.8	1 : 10
Cane tops	33.2	18.8	0.92	1 : 21
Maize (cut 1st tassel stage)	17.6	11.4	1.18	1 : 9
Maize (cut silk dried stage)	16.3	10.8	0.83	1 : 12
Maize (cut milk stage of grain)	20.0	13.4	0.82	1 : 16
Maize (cut glazed stage of grain)	25.7	17.4	1.00	1 : 16

TABLE I. *Nutritive Value of Fodders—Continued*

Fodder		D.M.	S.E.	D.C.P.	N.R.
Guinea corn					
(*Sorghum vulgare*)	(12 weeks old) ...	13.5	8.0	0.79	1 : 14
Imphee	(12 weeks old) ...	23.2	13.8	1.12	1 : 11
Kavirondo sorghum	(12 weeks old) ...	13.1	8.4	0.46	1 : 17
Legumes					
Woolly pyrol	(10 weeks old) ...	13.4	7.6	1.71	1 : 3.4
Phaseolus aureus No. 7	(10 weeks old) ...	10.9	6.1	1.56	1 : 3.0
Phaseolus aureus No. 23	(10 weeks old) ...	16.3	9.6	2.88	1 : 2.3
Phaseolus trinervius No. 8	(10 weeks old) ...	12.1	6.7	2.25	1 : 1.9
Alfalfa (Hairy Peruvian)	... ...	32.8	19.2	4.4	1 : 3.3
Pigeon pea	... ...	20.6	12.5	3.67	1 : 2.4
Silages					
Cane tops	... ...	37.9	24.1	1.11	1 : 21
Rounceval (*Vigna unguiculata*)	... ...	16.5	8.9	1.79	1 : 3.9
Sour grass	... ...	31.3	17.0	1.28	1 : 12.3
Maize	... ...	15.7	9.0	0.5	1 : 15
Imphee (Sp. *S. vulgare*)	... ...	17.5	11.0	0.7	1 : 14

NOTE :—Digestibility coefficients used in calculation of the above values were taken from Harrison, E.1942, and Morrison's book " Feeds and Feeding " 20th Edition, 1946.

Discussion

Several factors affecting the use of these fodders in rations for dairy cows in Barbados were noted :

(*a*) When compared with pasture roughages of temperate climates (Woodman, E. 1948), it was noticeable that the protein content generally, was appreciably lower. This has been noted for Trinidad fodders by Duckworth, 1949.

(*b*) Certain fodders which are commonly used as the basis of livestock rations in Barbados, including milking goats and sheep, namely sour grass and cane tops, have much higher dry matter contents than the temperate climate pasturages. The protein content of cane tops and sour grass would be considered average for tropical fodders. This high dry matter content tends to aggravate the deficiency of protein when fed to dairy cows, owing to the restriction imposed on bulk intake by the animal's capacity. It was necessary therefore to make up the maintenance requirements of protein with a concentrate before estimating the production concentrate ration, a factor which increases the feed bill considerably. In the case of the high yielding cows on the Central Livestock Station here, e.g., 35–40 lb. milk per day with an average of 4.2 per cent. butter fat, fodders such as these make it very costly to feed correctly, the quantity of concentrate required being high.

(*c*) Excluding legumes and some well made silages, the wide nutritive ratio of Barbados fodders e.g. 1 : 22 for 13 week old sugar cane, or 1 : 18 for 13 week old elephant grass, compare unfavourably with a nutritive ratio of 1 : 4.7 for extensively grazed United Kingdom pasture (average for the year Woodman, 1948). It has been proved in the temperate climates that a nutritive ratio of 1 : 6

is advisable when feeding dairy cows ; the use of Barbados fodders, green soiled, as the maintenance ration, unless cut very young at the sacrifice of reasonable yields per acre, is an expensive method of feeding. We have tried to counterbalance the protein deficiency and hence to lower the wide nutritive ratio in our fodders by making up a concentrate ration having a high protein content and thus a narrow nutritive ratio, i.e., 1 : 2.5 (approx.) This does not appear at present to be an entirely satisfactory solution to the problem.

It is not the experience with dairy cows at the Central Livestock Station that they consume reduced quantities of dry matter per 100 lbs. live weight as observed by Harrison, 1942. These cattle are probably higher grade animals than Harrison used for his work. The cows at the Station are a mixture of very high grade zebu-holstein crosses (at least 15/16ths) and very high grade zebu-guernsey crosses (at least 7/8ths). We have found that, with fodders such as guinea corn, and elephant grass cut at a succulent age, we were able to feed to a theoretical maintenance requirement with respect to digestible nutrients in conjunction with a high protein concentrate ration such as is given in Table II.

TABLE II. *Concentrate Mixture*

60 pts. Oil Meal.
30 pts. Dairy Feed (24% C.P.)
25 pts. Pollards.
20 pts. Coconut Meal.
25 pts. Sweet Potato Meal.
4 pts. Mineral Supplement (complete).

N.B.—This mixture has an estimated feed value of 91.2 per cent. dry matter, 76.6 per cent. starch equivalent and 20.28 per cent. digestible crude protein and was fed at the rate of 3½ lb. per 8 lb. milk. The average weight of 22 cows was 983 lb. with a minimum weight of 825 lb. and a maximum weight of 1,165 lb., the heavier recorded weights being those of the Holstein crosses.

Under these feeding conditions, which were only short-term, the animals maintained a satisfactory condition. This was not possible where cane tops, sour grass or mature fibrous elephant grass was concerned ; under these feeding conditions combined in the case of the two former fodders mentioned with the warm dry season of the year, a marked falling off in condition of the milking cows was noticeable.

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A NOTE ON COLONIAL GRASS

By

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Author's Summary

A trial, on small plots, of three methods of propagation is described ; local experience of management is mentioned ; and the chemical composition of the grass is compared with that of Elephant Grass (*Pennisetum purpureum*). It is concluded that, for the plant crop, a better yield results from propagation by stem cuttings, than by rooted sets (a sample of seed failed to germinate although previous experience has shown propagation by seed to be possible) ; the grass is suitable for soiling and, except in very dry weather, for grazing ; the chemical analysis of Colonial Grass suggests that it is a better quality feeding stuff than Elephant Grass.

Introduction

Colonial Grass (*Panicum maximum* var., Coloniao), a native of Brazil, is a long lived perennial with leafy and flowering shoots. It grows in dense tufts to a height of four to seven feet. It is closely related to Guinea Grass, which has a wider leaf blade and a less fibrous stem. The leaves of Colonial Grass are hairless, and when mature are about two feet long and one inch wide. This grass is becoming better known in the West Indies as a fodder. It can be grazed or soiled.

Propagation

Three types of planting material :

(*a*) stem cuttings ;

(*b*) rooted sets ;

(*c*) seed (imported from Venezuela)

were compared on small observation plots on the College Farm during August, 1947.

(*a*) Unrooted four-node stem cuttings were planted two per "hole", at $1\frac{1}{2}$ ft. × 1 ft. Each cutting was planted in a separate opening at an angle of 45-50° with the ground, with the buds placed laterally and with at least one node exposed. The soil was trodden firmly around the cutting.

(*b*) Rooted sets were planted upright, one per "hole" at $1\frac{1}{2}$ ft. × 1 ft. The soil was trodden firmly around the set.

(*c*) Seed, which was drilled in rows at $1\frac{1}{2}$ ft. and lightly covered with soil, failed to germinate, but previous experience has shown seed from the same source to be viable.

The following conclusions were the result of observations on small plots during the wet season :

Stem cuttings, although not giving the best results in establishment, gave the highest yield. It should be noted that since the flowering stalk of Colonial Grass is not very long vegetative planting material is likely to be scarce. Rooted sets gave fair results and used less planting material than the stem cuttings treatment, but the method takes severe toll on the field from which the planting material is taken. If viable seed were available, it should prove the most economical method of propagating Colonial Grass.

Management

Local experience suggests that for good results in dry weather, irrigation is necessary. Inter-cultivation soon after planting may control weed growth and by loosening the soil increase tillering propensity. It has been found on the College Farm that an application of sulphate of ammonia, at the rate of 1 cwt. per acre after each cut helps to maintain high grass yields.

For soiling during the wet season, cuts can be taken every eight to ten weeks. During the dry season the cutting interval may have to be extended to twelve weeks. Grazing during the wet season may be done when the grass is about six weeks of age. In Trinidad, dry season grazing appears to be very variable.

Nutritive Value

Table I shows, for comparison, part of the chemical composition of Colonial Grass and Elephant Grass at different stages of growth. Elephant Grass (*Pennisetum purpureum*) is a well-known fodder in the West Indies.

TABLE I. *Chemical Composition*

Season	Age (weeks)	Composition as offered to animls						Composition on a moisture free basis			
		Colonial Grass			Elephant Grass			Colonial Grass		Elephant Grass	
		Dry matter %	Crude protein %	Crude fibre %	Dry matter %	Crude protein %	Crude fibre %	Crude protein %	Crude fibre %	Crude protein %	Crude fibre %
	3	20.63	2.52	6.08	11.46	1.69	2.23	12.23	29.48	14.73	19.46
	6	27.25	2.79	8.07	10.95	0.35	3.14	10.24	29.63	12.31	28.66
Wet ...	9	31.77	2.61	9.25	18.05	1.14	6.16	8.21	29.13	6.29	34.15
	12	32.89	2.41	10.62	16.58	1.12	4.82	7.34	32.30	6.77	29.10

The chemical analysis of Colonial Grass shows a comparatively high crude protein value, both on a moisture free basis and when offered as green feeding stuff to animals. There is also slight variation in crude protein content when the green material is cut at different stages of growth. The crude fibre content of Colonial Grass, when offered as green feeding stuff, is higher than that of Elephant Grass, but on a moisture free basis, the crude fibre values are similar. The dry matter content of Colonial Grass is higher than that of Elephant Grass.

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